METAL INDUSTRY

25 APRIL 1958

Metallurgists and Management

SOME interesting points emerged from the address given by the President of the Institution of Metallurgists, Mr. J. Mitchell, in Birmingham last week, and in the subsequent discussion. It was suggested that on reaching the age of 30-35 a senior metallurgist should begin to delegate more of his actual metallurgical work to competent but more junior men, in order to leave himself more free to deal with the increased burden of administrative work which inevitably accompanies progress to higher posts, particularly in industry. Another suggestion implied that metallurgists should undertake the study of management subjects in order to facilitate this progress to higher rank. While on the one hand it was deplored that so few metallurgists achieve management positions it nevertheless seemed evident from the comments that many metallurgists themselves feel that for the majority, once a fair degree of laboratory and works experience has been achieved, there are greater rewards in administration and sales, than in pursuing a purely metallurgical course.

If these contentions are justified, surely the implication is that a high proportion of the most competent metallurgists virtually forsake their chosen profession just at a time when their training and experience have matured, and their employers should be reaping the full advantage of their metallurgical abilities. Are industrial leaders aware, we wonder, how much they lose by denying highly trained metallurgical personnel the adequate financial rewards and status which seem open to others ? There is no reason whatever to suspect that the training received by the metallurgist fits him any the less adequately for taking a leading part in management than the engineer or the accountant. In fact, the evidence is to the contrary, for his training in sifting and checking evidence, in understanding of cause and effect and in the application of scientific principles to the day to day task, is just the background required for a progressive executive who these days, more and more, is called upon to direct complicated and highly technical processes. It was said by Mr. Mitchell that a sense of vocation should be sought in recruits to the profession, and perhaps it is possession of this sense which frequently holds the mature metallurgist to the practice of his profession in preference to other more rewarding fields of promotion, and thus limits the numbers achieving executive rank. As a consequence, a cynical world deems him, like so many folk who confess to a vocation, happy enough to work conscientiously without the rewards which others claim as a right, and then despises him for being so content.

It cannot be just coincidence that in the U.S.S.R. where technical progress is so marked, the cream of the scientific students are directed into educational work and the scientist achieves a greater share of the material "perks" of the regime than anyone else. By comparison, material success in this country is far more readily achieved with an Arts than a Science degree whereas common sense indicates that the possessors of either have complementary tasks and therefore should each receive equal opportunity of prospects and ultimate status in the community. One thing is evident, we are moving steadily into an increasingly technical world where "know-why" is becoming a necessary prerequisite for "know-how" and if we are to hold our place in the commerce of the world, the technical man must be of the best and allowed to give of his best. He can only do so if the community is prepared to recognize his contribution to success and prosperity and to ensure that that contribution receives its just rewards.

Out of the MELTING POT

Picking the Unusual

No longer can there be any doubt that, at least in the best scientific and technical circles, the principle that even the queerest and most out-of-the-way phenomenon may be discovered to have one or two very useful practical applications, is now accepted without question. The only trouble remaining in this connection is that those who subscribe to this view are not always familiar with any such out-of-the-way phenomena, or do not know where to look for them, or may fail to recognize them when they happen to come across them. In the consequent absence of such phenomena, therefore, and not wishing to adopt the much more risky alternative of shooting into the blue, investigations are still often undertaken along lines indicated by what is no more than a process of intelligent but only slightly imaginative extrapolation. Naturally, shots into the blue are not announced until they happen to hit something useful. Investigations of out-of-the-way phenomena, on the other hand, are certainly worth announcing quite soon after they have got under way. This eliminates risk of duplication, and may also serve to attract interest, and with it useful information and comment. One such recent announcement has referred to an investigation being undertaken in America into the solubility of metals in their fused salts, e.g. chlorides. Hitherto, investigations into this phenomenon have been concerned chiefly with its mechanism—true solution *v.* formation of compounds—or with its nuisance value in fused salt bath electrolytic processes, in which solution of the metal in the fused salt, or the formation of a "fog" by some of the deposited metal, lowers the current efficiency of the process. The investigation now in progress is much more comprehensive, embracing, as it is ultimately intended to do, the whole of the periodic system, and much broader in its look-out for possible applications:—the purification of nickel (nickel is soluble in its molten chloride, while cobalt and iron have little or no solubility), the production of metal in special microcrystalline forms (whiskers(?), flakes) by controlled cooling of such solutions, the use of metal-in-salt solutions as controlled reducing agents, and (a shot into the blue, this one) high-temperature semi-conductors.

Putting Off the . . . .

However much we may analyse a given situation or problem into its constituents, however much we may be interested in details, however much we may concern ourselves with minutiæ, we cannot ever rid ourselves of the feeling that, after all has been said and done, the ultimate aim will always be to put it all together again into a single, integrated and complete system. However dormant this feeling may lie at the very back of our minds while we are preoccupied with the happenings of day-to-day business, it is always ready to burst forth and start conjuring up fair visions of what this business could be made into if only we could bring it into line and into a proper association with both its immediate and more distant surroundings. Alas, on all such occasions we finish up all too soon by realizing that, the complexity of the set-up being what it is, there can be neither the time nor the opportunity of our ever achieving the desired harmonious system of our vision. Small wonder, therefore, that a promise to the effect that this goal can now in fact be achieved should create enormous enthusiasm. This promise is based on the recognition that what is beyond our capacity in regard to both time and ability, is not beyond the capacity of suitable mechanical and electronic equipment. The latter needs only to be told what we should like to do (if only we had the time) and it will do it in a fraction of the time it would have taken us. Where we should find ourselves completely swamped by the detail comprising a really comprehensive integrated system, automatic data processing (ADP) will be able to cope without any difficulty at all. It will take into account all those factors which, in the past, we may have failed to consider, either because we were ignorant of their existence or, more probably, because we just did not have the time to collect the necessary information, to examine it, and to extract the necessary data. ADP will now do all this for us. There is just one snag:—it will present us with the final results. At first we shall be delighted to have them. Later, however, they will undoubtedly grow and multiply, and then we shall, likewise undoubtedly, find ourselves on occasions wishing that we were able, instead of dealing with them in detail, to link them up into a single, integrated, harmonious whole. . . .

Life-Timer

Watches and clocks are such common objects that the job of timing, for all practical purposes, of some process, operation, or the like is usually thought of as perfectly simple. This is perfectly true, provided somebody can be there on the job to watch the watch. The job becomes a little more complicated if there is nobody there to do the timing and if, in addition, the operation to be timed happens to be intermittent and/or to extend over a long period of time. In some of these cases, circumstances may be such as to rule out the possibility of using various conventional timing mechanisms: their bulk and weight may be too large or their cost too high. In such cases it is now possible to consider the possibility of using a very simple electrolytic timing device. This consists of a small glass cell with two sealed-in electrodes of platinum wire. The cell contains a solution of copper sulphate as the electrolyte, and the timing is done by noting the change in colour of the solution resulting from the deposition of copper by a small constant D.C. which is arranged to pass through the cell whenever the operation to be timed is in progress. The cell is connected into a circuit in series with a resistor, the value of which is chosen to suit the voltage of the supply and the length of the time to be measured. The colour change is determined using a colorimeter calibrated directly in elapsed time. Simpler still, the time can be determined by comparing the colour of the solution with a standard colour chart. The device enables elapsed time to be measured with an accuracy of ±5 per cent for a range of from 250 to over 5,000 hours. Commercial applications of this simple time measuring device are envisaged in connection, for example, with costly electronic equipment, e.g. colour television tubes, which is sold with a length of life guarantee.

Skimmer

RELATIVE BEHAVIOUR OF 85:5:5:5 GUNMETAL AND TWO HOT-STAMPED BRASSES AT 205°C.

Creep Properties of Three Copper Alloys

By J. McKEOWN, D.Sc., M.I.Mech.E., F.I.M. and R. D. S. LUSHEY

This article records an investigation carried out by the British Non-Ferrous Metals Research Association which was communicated to members of the Association in Technical Memo. 141 (Revised) March, 1958. The authors are both at B.N.F.M.R.A., Dr. J. McKeown as Head of the Mechanical Testing Section and Mr. Lushey as Research Assistant.

IN recent revisions of British Standards for certain valves operating at elevated temperatures, questions have arisen concerning the maximum service temperatures at which hot-stamped brass components are suitable. This report describes creep tests designed to help resolve these questions. Cast 85:5:5:5 copper-tin-zinc-lead gunmetal and a hot-stamped leaded 60:40 brass have been tested at 400°F. (205°C.).

The tests have been carried out for a duration, where appropriate, of 10,000 hr. (14 months) and have enabled definite conclusions to be reached on the relative resistance to creep of the two materials.

The gunmetal was cast as plate castings ¼ in. thick in the works of a member firm, a charge of 500 lb. being used. The metal was melted in an oil-fired crucible furnace and was scavenged with nitrogen for 5 min. before pouring.

The surfaces of the plates were machined, about $\frac{1}{32}$ in. being removed, to provide suitable specimens from which creep and tensile test pieces could be machined.

In the case of the brass, 0·708 in. diameter rod was extruded at 650°C. through a four-hole die from a 17 in × 7 in. diameter billet. Half of this rod was hot-stamped at 680°-700°C. and half at 790°-820°C. to give samples from which, after surface machining, creep and tensile test pieces were machined.

The analyses of the materials are as shown in Table I.

The room temperature properties of the materials are given in Table II.

All the tests were made at 400°F. (205°C.) in B.N.F. type creep-testing machines. The test pieces were raised to temperature over a period of 4 to 6 hr. and the temperature stabilized during a further 20 hr. before the stress was applied. The temperature was maintained to ±1°C. throughout a test and in the creep tests the strain was measured to a sensitivity of 2×10^{-5} (0·002 per cent).

Detailed results of all the tests are given in Table III. Fig. 1 shows the results of stress-rupture tests which, in the case of the gunmetal, have been made at high stresses only. Reference to Table III shows that the elongations of the brass specimens at fracture were high, but there is some indication that ductility is falling slowly with increased life of specimen. In the case of the gunmetal, there was a marked drop in ductility at the lower of the two stresses it was possible to use. When attempts were made to test this material at higher stresses, rupture occurred during loading of the test pieces, and this is shown by the dotted line in Fig. 1.

The relationship between stress and

TABLE I—ALLOY COMPOSITION

Material	Composition (per cent)									
	Cu	Zn	Sn	Pb	Ni	Fe	Sb	As	P	Bi
85:5:5:5 Gunmetal	84·7	4·1	5·4	4·9	0·42	0·05	0·24	0·09	0·04	0·011
Brass	57·7	39·72	0·16	2·17	0·08	0·12	Al 0·02	Si 0·02	Mn 0·01	—

TABLE II—ROOM TEMPERATURE PROPERTIES

Material	0·1 per cent Proof Stress (tons/in²)	Tensile Strength (tons/in²)	Elong. per cent on $4\sqrt{A}$	Youngs Modulus lb/in² ÷10⁶	Hardness V.P.N.
Hot-stamped brass (680–700°C.)	13·2	29·6	34	15·0	115
Hot-stamped brass (790–820°C.)	10·9	28·5	35	15·1	105
85:5:5:5 Gunmetal	—	12·3	11	—	—

Fig. 1—Stress-rupture time tests at 400°F.

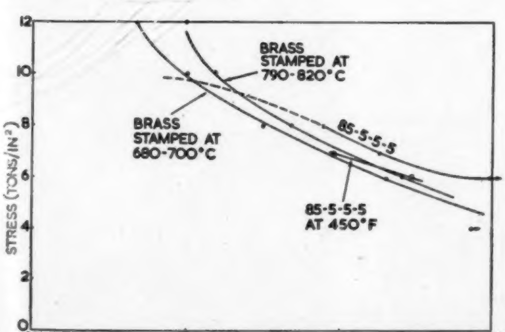


Fig. 2—Stress to produce 0·1 per cent plastic creep strain at 400°F

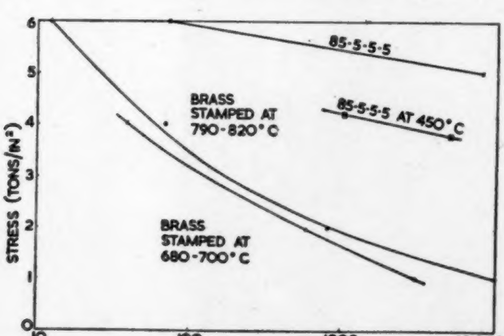


TABLE III—CREEP TESTS AT 400°F. (205°C).

Material	Stress (tons/in²)	Plastic Creep Strain per cent at: (hr.) 100	500	1000	1500	3000	5000	7500	10000	Duration of Test (hr.)	Extension per cent on $4\sqrt{A}$	Min Rate of Creep or Rate at 5,000 hr (Strain/hr.)
85:5:5:5 Gunmetal	12		Fractured during application of load								6	
$E=12{\cdot}5\times10^6$ lb/in²	8				Stress rupture test					766	2	
	7			"	"	"				1756	<1	
	6	0·102	0·124	0·132	0·142	0·162	0·180	0·200		9576D		8×10^{-8}
	5	0·046	0·054	0·060	0·066	0·076	0·084	0·102		9000D		6×10^{-8}
	4	0·018	0·022	0·028	0·032	0·040	0·046	0·050	0·054	10000D		2×10^{-8}
	2	<0·002	0·004	0·006	0·008	0·010	0·012			5600D		$<1\times10^{-8}$
	1	<0·002	0·004	0·004	0·004	0·004	0·006			5600D		$<1\times10^{-8}$
Brass	12				Stress rupture test					48	67	
Hot-stamped at	10				"	"	"			100	61	
680–700°C.	8				"	"	"			319	62	
$E=12{\cdot}8\times10^6$ lb/in²	6				"	"	"			1992	51	
	4				"	"	"			7300	44	
	6	0·676	5·42							600D		
	4	0·176	0·564							624D		
	2	0·044	0·094	·0138	0·178	0·292	0·448	0·662	0·950	10000D		8×10^{-7}
	1	0·022	0·048	0·060	0·076	0·104	0·136	0·176	0·230	10000D		2×10^{-7}
	½	0·010	0·018	0·026	0·030	0·036	0·038	0·046	0·052	10000D		2×10^{-8}
Brass	12				Stress rupture test					94*	52*	
Hot-stamped at	10				"	"	"			151	53	
790–820°C.	8				"	"	"			480	50	
$E=13{\cdot}2\times10^6$ lb/in²	6				"	"	"			2520	49	
	6	0·424	0·558 at 144 hours							144D		
	4	0·132	0·492							600D		
	2	0·036	0·078	0·112	0·146	0·210	0·296	0·400	0·530	10000D		4×10^{-7}
	1	0·012	0·026	0·038	0·050	0·058	0·070	0·078	0·85E	9220D		3×10^{-8}
	½	0·006	0·020	0·022	0·024	0·025	0·028	0·031	0·024	10000D		1×10^{-8}

D = Test discontinued. *E = Extrapolated.*

**Specimen unbroken but limit of extension in machine reached. Both life and extension would be slightly greater than given above.*

time to produce 0·1 per cent plastic creep strain is shown in Fig. 2. From this figure it is clear that the gunmetal has considerably greater resistance to creep than the two hot-stamped brasses. At the low stresses of 2 and 1 tons/in² the rate of creep of the gunmetal is so low as to be hardly measurable, whereas at these stresses the hot-stamped brasses are creeping at a readily measurable rate. The stress required to produce 0·1 per cent plastic creep strain in 10,000 hr. is frequently cited as a design criterion, and the stresses for the two types of material are of the order of 4 to 5 and ½ to 1 ton/in² respectively.

The higher stamping temperature used with one lot of the brass produced a slight improvement in creep resistance with a slightly longer life, but a slightly lower ductility in the stress-rupture time tests. The microstructure of the two brasses shown in Figs. 3 and 4 offers an explanation of this difference, coarser microstructure being in general conducive to higher resistance to creep but resulting in lower ductility under creep conditions. The microstructure of the 85:5:5:5 gunmetal is shown in Fig. 5.

The stress-time relationships for the three materials tested are given in Figs. 6, 7 and 8, and show clearly that in the case of the gunmetal there is a likelihood that in very long times under the stresses at the temperatures of the order considered here, fracture will occur with an extension of less than

Fig. 3—Microstructure of brass hot-stamped at 680°-700°C. (×100)

Fig. 4—Microstructure of brass hot-stamped at 790°-820°C. (×100)

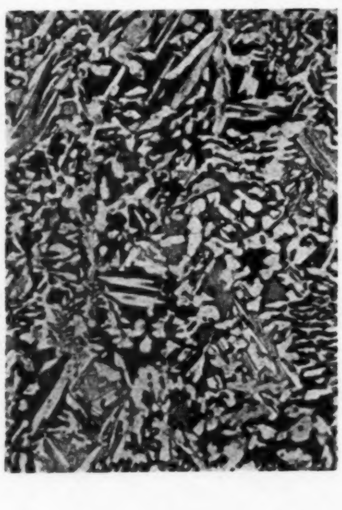
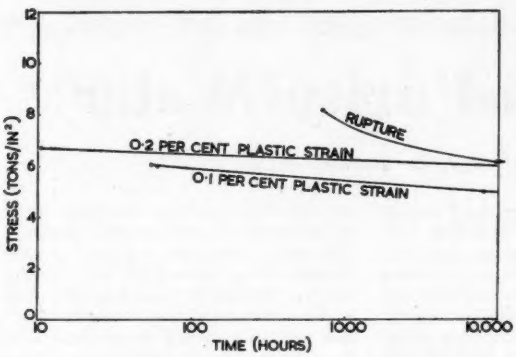
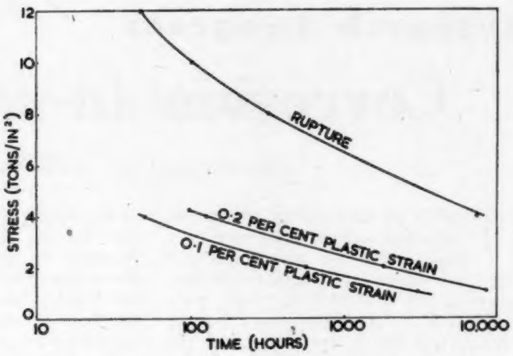


Fig. 5—Microstructure of 85:5:5:5 gunmetal (×10)

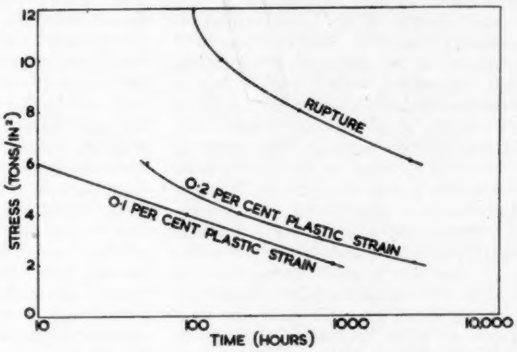




Above : Fig. 6—Stress-time relationships for 85:5:5:5 gunmetal at 400°F.

Above right : Fig. 7—Stress-time relationships at 400°F. for brass hot stamped at 680°-700°C.

Right : Fig. 8—Stress-time relationships at 400°F. for brass hot stamped at 790°-820°C.



0·2 per cent, whereas there is no indication of such "short" fractures in either of the two brasses.

In practice, cast gunmetal valves have given long and satisfactory service at temperatures of the order considered here, and it must be assumed in the light of these test results that the stress levels in such valves are far below the 4 to 5 tons/in^2 level mentioned above. This view is consistent with the results of tests carried out by the Mechanical Engineering Research Laboratories for a member firm to determine the stresses developed in the walls of such valves by internal pressures up to and beyond the maximum service pressures. The results indicate that the stresses imposed on the material in service are of the order of only ½ ton/in^2. The present creep test results must be taken as a warning that any attempt to raise the operating stress to levels of the order of several tons/in^2 would entail a serious risk of "short" failure. They may also be taken to indicate that the higher resistance to creep of the gunmetal, compared with that of the brass, can only be exploited to a limited extent.

Men and Metals

Managing director of The Non-Ferrous Die Casting Company Limited since that company's inception, **Mr. N. D. G. Robertson** has resigned from the board, but he will continue to act for the company in the capacity of consultant. He is being succeeded as managing director by his son, **Mr. N. D. G. Robertson, Jr.,** and **Mr. G. C. Praill** has been appointed a director of the company.

At the annual general meeting of the Federation of Light Metal Smelters, **Mr. R. Hahn** (B.K.L. Alloys Limited) was appointed chairman for the ensuing year in succession to **Mr. B. Endlar** (John Dale Limited). **Dr. J. Jakobi** (International Alloys Limited) was appointed vice-chairman. The Council for the ensuing year consists of the chairman, vice-chairman, the retiring chairman, and **Mr. O. G. Halliwell** (J. Frankel (Aluminium) Limited), **Mr. R. Hopkins** (John E. Moore Limited), and **Mr. E. W. Nicholls** (The Wolverhampton Metal Company Limited).

It is announced by the Institution of Incorporated Plant Engineers that **Mr. R. F. Farmer,** who has been assistant secretary since 1952, has been appointed secretary of the institution in succession to Mr. Hadleigh S. Seaborne.

Two members of the staff of the Department of Metallurgy of the College of Technology, Birmingham, have recently been awarded Ph.D. degrees. The first is **Dr. J. C. Wright,** who recently joined the staff of the department as a senior lecturer. He obtained a 1st Class Hons. External B.Sc. (Engineering) Metallurgy degree of the London University in 1954 after studying as a part-time student at the Birmingham College of Technology for several years. His thesis was the result of work carried out at the Wolverhampton and Staffordshire College of Technology, where he held a Senior Research Fellowship sponsored by the Ministry of Fuel and Power. The research was on the problem of ash deposition with solid pulverized fuels in gas turbines, and the title of his thesis was "Some Problems of Ash Deposition in a Peat-Fired Gas Turbine." The second award was made to **Dr. H. R. W. Thresh,** who joined the staff of the department at the College some 18 months ago as a lecturer. He graduated with 1st Class Hons. from Birmingham University and, after a brief period in industry, returned to the University with a Research Fellowship, eventually submitting a thesis on "The Viscosity of Liquid Metals."

Changes in group organization have been announced by Vickers Limited as follows:—**Mr. J. H. Robbie,** C.A., is appointed a director of Vickers-Armstrongs Limited. **Mr. E. P. Tomlinson,** A.C.A., is appointed commercial director of Vickers-Armstrongs (Engineers) Ltd. **Mr. A. Lawrence Cooper** is appointed secretary of Vickers Limited, and **Mr. J. McLean,** A.C.A., is appointed deputy secretary. **Mr. T. P. Houghton,** A.C.A., is taking over the position as secretary of the following companies — Vickers-Armstrongs (Aircraft) Limited, Vickers-Armstrongs (Engineers) Limited, Vickers - Armstrongs (Shipbuilders) Limited, and Vickers-Armstrongs (Tractors) Limited. **Mr. T. C. Raymond** has been appointed a special director of Vickers - Armstrongs Limited.

Research Progress

Corrosion in High-Purity Water

BY RECORDER

USAGE of high-purity water has increased substantially in recent years. The two most important fields in which this expansion has occurred are the chemical and electricity-generating industries. In the former, the water is needed in the manufacture of special chemicals, particularly those to be used pharmaceutically; in the latter, increased efficiency can be obtained by removing those impurities in water which adversely affect heat transfer, or which give rise to deposits that impair the working of the plant. The state of purity of the water is of even greater importance in certain types of nuclear power reactor, where the heat generated by fission is removed by using circulating water, owing to the additional disadvantage that impurities can give rise to radioactive deposits in parts of the system remote from the fuel elements. The corrosion of plant in contact with such water is, therefore, being studied extensively, and several Papers on this subject were presented at the Thirteenth Annual Conference of the (United States) National Association of Corrosion Engineers last year.

Influence of Water Purity

As one of the authors, R. R. Dlesk, points out,[1] the term "high-purity" water requires definition. At present, "water low in hardness, silica and dissolved gases, with an electrical resistance of approximately 500,000 ohm-cm." is considered to be of high purity; future developments, however, will necessitate the use of water having an electrical resistance of from 1 to 10×10^6 ohm-cm. Dlesk goes on to say that the increase in purity of water used in steam-generating plants has been accompanied by an "almost proportional" increase in the corrosion rate of steel water-storage tanks. It is not clear, however, whether this increased attack is due only to the elimination of impurities from the water since other conditions, notably the temperature of the water, may also have changed. Indeed, in most of the Papers being considered there seems to be no clear-cut distinction between problems associated with changes in water purity and those introduced by more arduous service conditions.

Dlesk describes tests on the corrosion of various materials suitable for storage tanks, carried out by the Commonwealth Edison Co., Chicago. Coatings of red-lead paints with phenolic resin and linseed oil bases, of metallic zinc paints, of synthetic rubber, and of a nickel-phosphorus alloy were found to be unsatisfactory as a protection for steel, either because the coating itself was attacked sufficiently to introduce impurities into the water or because penetration of the coating occurred. A heavy electrodeposit of nickel (0·008 in. thick) appeared to give adequate protection, but a less costly material was desired. Eventually it was found that 3003 aluminium (containing 1·2 per cent manganese) resisted attack without giving rise to deleterious aluminium contents in the water. Preconditioning of the tanks by filling them with various types of water was assessed by measuring the resistance of the oxide film found on the aluminium. These tests indicated that a high-resistance film could be built up by 1-3 weeks' contact with distilled or demineralized water, local tap water or "extremely pure" demineralized water being less effective. It was also found that the pretreatment in the latter water could be accelerated by the presence of one part per million of ammonia. Satisfactory service has since been given by four 44,000 gal. tanks in this alloy, the water temperature being 120°F. minimum.

Similar good results using 3003 aluminium for high-purity water storage are reported elsewhere by W. W. Binger and C. M. Marstiller, of the Alcoa Research Laboratories.[2] Their tests were extended to temperatures up to 314°C. For exposures of the order of 120 hr., a very rapid increase in the rate of attack was obtained at 268°C. when steam was present. Attack by water at this temperature was not so severe, however.

Nuclear Reactor Applications

Other aluminium alloys, 1245 and M-388 (the exact analyses of which are not given), were tested by R. J. Lobsinger and J. M. Atwood for use as nuclear fuel element jackets.[3] In their experiments, deoxygenated, deionized water containing 0·1 p.p.m. maximum dissolved solids was passed through an annulus between the aluminium sample under test and a surrounding Zircaloy-2 tube. The pH of the water could be adjusted from 5·8-6·2 as obtained with mixed-bed deionization, to 5·3-5·6 by using a cation exchange resin. Lower pH values of 4·5-5·0 were obtained by injecting phosphoric acid into the water.

Weight loss measurements of exposed samples from which the corrosion products had been removed chemically were made, using various water temperatures up to about 250°C. Although it is suggested in the Paper that the specimens were situated in a reactor loop for the duration of the experiment, no information about the radiation conditions is given. Another complicating feature of this work lay in the observation that corrosion rates were very dependent on whether or not heat was being transferred to the water through the aluminium during the test. Without heat transfer the temperature of the corroding surface could be taken to be that of the circulating water. The transfer of heat increased the surface temperature, the value of which could then only be assessed by comparison of the corrosion rates obtained with and without heat transfer. An "effective" surface temperature was thus obtained which was found to influence the corrosion rate markedly.

Lobsinger and Atwood state that the corrosion rate varied linearly with the reciprocal of the effective surface temperature down to 125°C. Below this value, the scatter of the results was too severe to enable a correlation to be established. Reference to their data suggests, however, that the correlation is dubious, owing to scatter, for temperatures appreciably higher than 125°C., and in tests at pH 5·3-5·6 the corrosion rate is hardly predictable within a factor of 10 for temperatures up to about 180°C. The authors also say that the corrosion rates of the two alloys 1245 and M-388 are the same, but the data to which one is referred for evidence of this result do not, in fact, indicate which tests were carried out on alloy 1245 and which on M-388. The injection of phosphoric acid reduced considerably the corrosion ratio at temperatures exceeding about 180°C., though the results presented for lower temperatures indicate that the low pH thus obtained may have little or no beneficial effect.

Film Growth

Also concerned with reactor fuel elements, F. H. Krenz describes with more detail experiments carried out on aluminium alloys containing small quantities of nickel, iron, copper and silicon.[4] Static tests in an autoclave and dynamic tests with flowing water were made at temperatures up to 300°C. In one series of alloys, containing 0·5 or 2·0 per cent nickel, 0·5 or 1·0 per cent iron and 0·0, 0·2 or 0·5 per cent silicon, the best results, judged by weight gain and visual assessment of attack, were given by the materials containing 0·5 per cent iron, 0·2 per cent silicon and either 0·5 or 2·0 per cent nickel. In another group of alloys containing 0·5, 1·0 or 2·0 per cent nickel plus 0·0, 0·5, 1·0, 2·0 or 4·0 per

(*Continued on page* 333)

Pressure Die-Casting Review

Design of Die-Castings

VII—Means of Attachment for Die-Cast Components

By H. K. BARTON

A FACTOR of considerable importance in the design of die-cast components is the provision of features that facilitate assembly, and a most important means of accomplishing this is the use of integral means of attachment. There are three classes of assembly operation in question; the attachment of subsidiary components to die-castings, the securing together of two or more die-cast components, and the mounting of die-castings upon non-die-cast articles. Typical examples of each are, respectively, the attachment of stamped name-plates to die-cast housings of domestic appliances and the like; the assembly of right- and left-hand die-castings to form such assemblies as spiral exponential car horns; the use of die-cast insignia and "trim" on refrigerators, stoves, and similar light steel pressings.

The means adopted in any particular application are, however, more usefully classified according to the extent to which the assembly is a critical one; on this basis, one can divide assembly operations into (a) those demanding secure attachment only and not entailing exact dimensional relationship between the two elements of the assembly (the first and third of the examples above fall under this head); (b) those requiring precise alignments of the elements assembled but not entailing relative motion of the elements after assembly; and (c) those calling for precise alignments and clearances so as to permit relative motion within the assembly.

Where secure attachment is the criterion, and the assembly is not required to be demountable, the simplest method is usually by the provision of integral rivets to be headed over at assembly. The great ductility of the zinc-base alloys, which allows die-cast rivets to be peened, staked or spun, renders this method particularly attractive. Although integral rivets can be formed on aluminium die-castings, the casting alloys are not well suited to subsequent deformation and it is, therefore, preferable, where rivetting is required, to utilize standard aluminium rivets of a softer and more ductile alloy.

The desiderata for die-cast rivets are in large measure the same as for all die-cast studs; as noted in an earlier article, they should have either a fillet or a shallow annular groove at the base to reduce the likelihood of fracture and to facilitate location in holes that have not been deburred (Fig. 1). It is also desirable to make them as stout as possible in order to prevent air inclusions and brittleness due to premature chilling, though should the web from which they spring be thin, there is a limit on the diameter (at root) that can satisfactorily be adopted. In general, rivet diameter should not exceed the web thickness by more than about 25 per cent.

Whatever the web thickness, solid rivets should not exceed $\frac{1}{4}$ in. or $\frac{5}{16}$ in. diameter, nor be less than $\frac{3}{32}$ in. diameter. Where attachment alone is in question, and the proportions of the component allow, rivets of $\frac{3}{16}$ in. diameter may well be adopted. These are large enough not to chill too quickly, but not so large as to cause a hot spot on the opposite face of the component. If possible, rivet lengths should be less than three times the diameter—not so much because of difficulties in producing longer ones as because the presence of very long rivets makes handling difficult. There are, however, many opportunities for modifying the design of die-cast parts and it is seldom that excessively long rivets cannot by some means be eliminated.

In applications where two die-castings are to be rivetted together, it is often a matter of indifference which one bears the integral rivets so far as assembly is concerned. However, even if there is some advantage in having the rivets formed preferentially with one of the elements, it is desirable to discuss the matter with the die-caster before making a final decision, since rivet location often has profound effects upon die design and, in consequence, upon the ease and speed with which the component can be produced.

A rather obvious example is the undesirability of locating integral rivets with their axes parallel to the die parting, as in Fig. 2, since they can only be produced if one side of the cavity is made to slide laterally to clear them. If the rivets are the only features demanding a sliding die element, it is almost certainly preferable to adopt some other means of attachment or, should it be possible, to form the rivets integrally with the other portion of the assembly. Nevertheless, when the die-casting embodies some essential feature that cannot be produced other than by utilizing a sliding die element, it may well be desirable to design this lateral slide so that it can also form the integral rivets, as in the example of Fig. 3.

A factor of some generality is the preferability of locating integral rivet

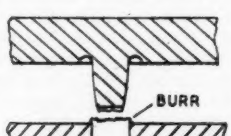
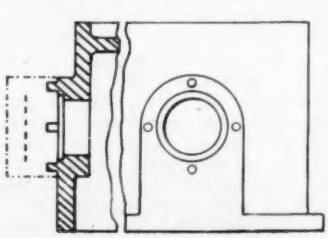


Fig. 1—It is unnecessary to deburr the cored hole before assembly if the mating rivet is recessed at the base

Fig. 3—Here a functional element, the recessed bore, entails the use of a sliding core: the integral rivets can thus be provided without increasing the complexity of the tool



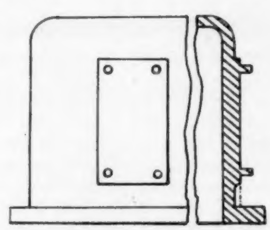
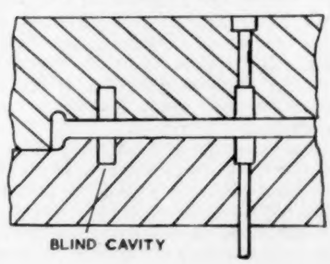


Fig. 2—The cost of production is sharply raised when lateral slides are incorporated in the die to produce features such as the rectangular pad with integral rivets in the figure. The pad should be carried down to the flange and other means of attachment devised

Fig. 4—The best position for a rivet is lower right in the figure; the next best upper right, where a venting pin closes the cavity and allows air to escape fairly freely. Blind rivet cavities (left) are seldom satisfactory



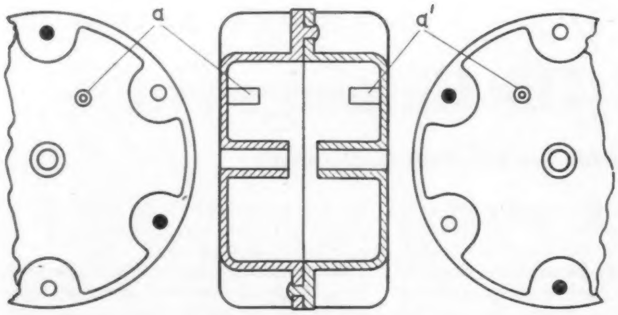


Fig. 5—An assembly of two identical die-castings ("self-assembly")

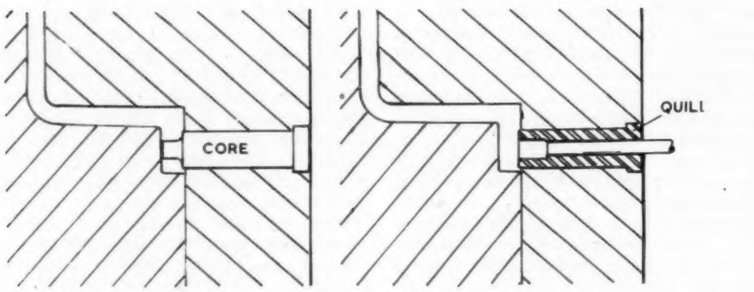


Fig. 6—The cores and quills respectively forming holes and rivets may advantageously be made interchangeable

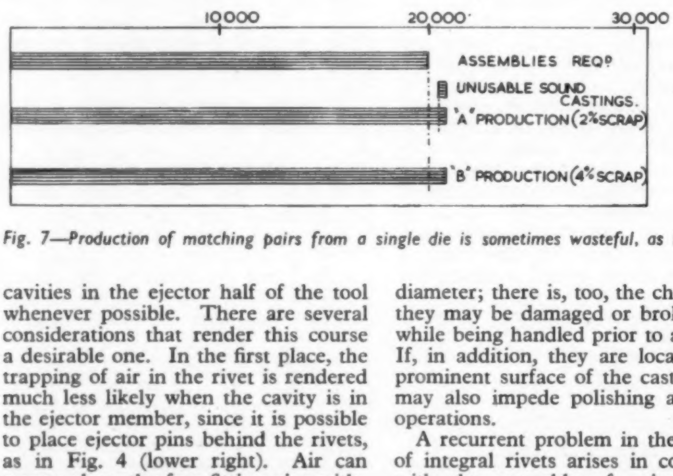


Fig. 7—Production of matching pairs from a single die is sometimes wasteful, as here shown

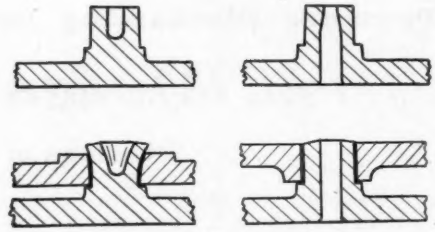


Fig. 8—Assembly by spreading the internal bore of a hollow rivet

cavities in the ejector half of the tool whenever possible. There are several considerations that render this course a desirable one. In the first place, the trapping of air in the rivet is rendered much less likely when the cavity is in the ejector member, since it is possible to place ejector pins behind the rivets, as in Fig. 4 (lower right). Air can escape along the free-fitting pins without difficulty, whereas in a completely blind cavity (top and bottom left, respectively) either air inclusions or short runs may occur intermittently.

This is a point of very great importance, since a single imperfect integral rivet entails the rejection of the component even though it be perfect in all other respects. Other things being equal, the smaller the rivet diameter the more likely it is that imperfections will occur with some frequency, and die-casters, therefore, often look askance at designs for die-castings that embody very small integral rivets for attaching, say, a sheet-metal instructions plate. It is, of course, not only the likelihood of casting imperfections that arises when rivets are of small diameter; there is, too, the chance that they may be damaged or broken away while being handled prior to assembly. If, in addition, they are located on a prominent surface of the casting, they may also impede polishing and other operations.

A recurrent problem in the location of integral rivets arises in connection with the assembly of pairs of die-castings that are substantially identical in form, like the circular, dish-shaped housings of which an assembly section is shown in Fig. 5. The way in which they are assembled is clearly seen; a short rivet projecting from one casting passes through a cored hole in the other and is spread by staking. The rivets (shown black), and their mating holes, are located on flat pads which are formed within indentations of the circular perimeter as indicated.

Two courses are open to the designer; he may either make the two housings identical except for the rivets, these all being in one housing and all the holes in the other, or he may alternate rivets and holes around the perimeter, providing, say, three rivets and three holes on each, as in the example illustrated. In the first case, the castings must be paired up for assembly, whereas in the second, any two complete components taken at random can be assembled together. The positioning of the rivets must, of course, be referred to the desired relationship of any functional elements of the castings, such as the small cored bosses *a*, *a'* in Fig. 5, which can only be placed midway between a rivet and a hole.

For ease of assembly it is, on the face of it, preferable for all the rivets to face the same way; if they are to be spun over, or staked individually, the time required to turn the assembly over and relocate it in the fixture is appreciable. If provision is to be made for staking all the rivets simultaneously, on the other hand, there is no great difficulty in devising a spring-supported nest for the component so that staking punches in both top and bottom of the tool may operate at a single stroke of the press.

To the die-caster, the difference is a more important one, since the issue is between producing two distinct die-castings and producing one in twice the quantity. If the casting is of a size to permit the use of a single-cavity die only, it is necessary to take into account the number of castings likely to be required before deciding upon the best production method. If a hundred thousand or so of each half were required, to be delivered over a period of three or four months, the construction of a separate die for each half would probably be thought justified.

There is no doubt that, if separate dies are constructed, one should produce a component bearing all the rivets and the other a component with all the holes. One of these being completed and tested first, and samples checked dimensionally, the other can be constructed so that rivets and holes mate exactly. All assemblies will then be identical, i.e. if one die is termed *A* and the other *B*, all assemblies will be *AB*. If, by contrast, two dies are constructed to produce self-assembling components, each casting having half the complement of both rivets and holes—the use of two dies being assumed necessary to maintain the required delivery rate—it is by no means so easy to guarantee the same ease of assembly. In addition to true

"self-assemblies," where both components are from the same die—*AA* and *BB*, it is inevitable that some mixing of the castings will result in cross-assemblies *AB*. Whereas it is a simple matter to adjust rivets and mating holes in either *A* or *B* to make self-assembly easy, it is much more difficult to make both self- and cross-assemblies equally precise.

For a lesser quantity of parts, justifying the construction of a single die only, an alternative method of production is to use a tool having interchangeable inserts. For the component of Fig. 5, the only modification needed is to replace a fixed core by a quill for the rivet cavity, as shown in the part sections of the tool in Fig. 6. It is thus possible for the die-caster to operate the die for two or three shifts, producing a few thousand of one component, and then to change over the inserts for production of an equivalent batch of the mating part. With such a tool, it may be noted, it is also possible to alternate the cores and quills of Fig. 6 and so produce a self-assembling component. Because of this operational flexibility, as much as to facilitate replacement of damaged parts, a die-caster is, in any case, likely to adopt the same diameter for cores and rivet quills when designing a tool for identical castings assembled with integral rivets.

Instead of production from two separate dies, it may well prove that a two-cavity die on a heavy-duty machine is a more effective method. This still leaves the issue of whether the two cavities should produce components for self-assembly or for cross-assembly. Although the latter course may seem the better solution—the tool then producing a pair of castings at each shot—the die-caster is likely to be influenced by the possibility, always to be borne in mind, that one cavity will have a higher incidence of faulty castings than the other. In the instance here envisaged, the component with rivets will probably be more susceptible to casting defects. This being the case, a run of 20,000 shots with a scrap rate of, say, 2 per cent on one cavity and 4 per cent on the other, will result in a deficit of 800 rivet bearing castings and 400 of the others. To make up the balance to 20,000 pairs requires an overrun of more than 800 shots (Fig. 7), but 400 or so of the 800 hole-bearing components produced will then be surplus.

This can be avoided by constructing the die with two identical cavities for self-assembling components, and in this case the fact that *AB* assemblies will occur as well as *AA* and *BB* assemblies is much less of a disability. The housings for both arrays of cores and quills being jig-bored at the same setting, the chance of significant variation between the respective inter-centre distances of any two pairs of housings is small. All three types of assembly can accordingly be expected to be satisfactory, and it is unnecessary to batch the components from the two cavities separately. Whatever the respective scrap rates of the cavities, therefore, there are never any surplus castings that cannot be matched.

Although the foregoing comments have referred specifically to assemblies utilizing conventional integral rivets, they are, in fact, quite generally applicable. It is probable that quite a large proportion of applications in which rivets are adopted as a means of attachment could be simplified or improved by the adoption of one or other of the many related methods that are possible to—in some cases are specific to—the die-casting process.

For example, there are often advantages in using hollow or semi-tubular rivets (Fig. 8) instead of solid ones, particularly when small non-rotatable parts are to be assembled with the main die-casting. Such rivets can be clinched either by spinning or by spreading the ends with a dished punch, but it is also possible to use a drifting punch, which expands the wall outwards within the bore of the mating part. This gives an attachment more resistant to rotation than in an ordinary clinch, without the need to form the mating part with a non-circular hole.

Where the wall of a die-casting is to be expanded in this way, it is desirable to use a slightly ribbed or fluted taper punch, which generates more frictional heat as it enters the bore and is less likely to split the wall than a plain tapered punch. As will be evident, it is advantageous in the case of semi-tubular integral rivets (Fig. 8, left) to have as little taper on the bore as possible. Where the rivet, or pillar, is hollow, as on the right, it may advantageously be cored from the basal end. This allows the wall to be thickened a little at the outer end. The spreading punch can be entered from whichever end is the more convenient. The method is well adapted to large bores, but since these are likely to have some functional use, as well as serving for attachment, the flutes or ribs will normally need to be omitted from the punch. This then resembles an ordinary bull-nosed burnishing punch. A drop-through punch, retrievable from a chute beneath the press, is often adopted. One particular application for which the method can be recommended is the securing of external bearing sleeves. Bushes are held by their outer surfaces and, in consequence, can be cast in place, but annular inserts are not easily anchored unless provided with deep internal grooves. It is, therefore, generally preferable to use a plain sleeve cut from tube, and to assemble it under a press. This can be done by making the annulus and the neck of the component an interference fit and pressing them together, but the tube can easily be distorted. By making the casting an easy fit in the insert, and spreading the neck with a punch, the possibility of distortion is minimized.

(To be concluded)

Research Progress—*continued from page 330*

cent copper, the material with 2·0 per cent of each element appeared to be the most promising. Both sets of experiments were carried out in autoclaves at 300°C.

The three alloys giving the lowest corrosion rate without undue localized attack were next tested under static conditions for several weeks at 300°C. It was found that the film formed consisted of two layers, the inner of which grew linearly with time of exposure. The outer film grew rapidly to a thickness of about 10 microns and thereafter remained constant. In dynamic tests, however, the outer film could not be distinguished after immersion and the inner film was shattered at many points. Much of this damage may have been caused by vibrations set up in the sample from the pump circulating the water. With water velocities of 18-20 ft/sec., corrosion rates of 0·020 in/yr. to 0·030 in/month were obtained, depending on whether the sample was clamped rigidly or allowed freely to vibrate.

Finally, Krenz describes the performance of actual fuel elements sheathed with one of the above alloys (2 per cent copper-2 per cent nickel). The sheath was exposed to water at 288°C., 2,000 lb/in^2 static pressure and flowing at 18 ft/sec. A heat flux of about 100 watts/cm^2 and, presumably, some neutron flux, were also transmitted through the sheath. A corrosion rate of about 0·010 in/month was obtained in tests lasting up to at least 6 weeks. Again, mechanical damage to the corrosion film was found, indicating the need to improve the alloys either by reducing the thickness or increasing the strength of this film. Additional high temperature strength of the alloy would also help to reduce the stresses imposed on the corrosion film.

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2 W. W. Binger and C. M. Marstiller; *ibid*, 59.
3 R. J. Lobsinger and J. M. Atwood; *ibid*, 50.
4 F. H. Krenz; *ibid*, 43.

Internal Welds

FOR automatic welding of internal seams, Quasi - Arc Limited, of Bilston, Staffs., are producing a high lift internal welder, making possible the welding of internal longitudinal seams in vessels from only 30 in. or up to 10 ft. diameter and up to 10 ft. long. The equipment can also be used for internal circumferential seam welding at diameters of 2 ft. 6 in. and over, and for external seam welding of vessels up to 10 ft. diameter.

INFILTRATION OF POWDER COMPACTS — PRODUCTION OF FILTERS

Porous and Infiltrated Metal

By J. E. ELLIOTT, B.Sc., A.I.M.

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INFILTRATION is a technique which can be applied to certain combinations of metals, whereby the voids of a porous metal skeleton may be filled with another metal, while in the molten condition, by means of an infiltration mechanism, depending for its action upon surface tensional forces. Six conditions must be satisfied in order to achieve useful infiltration. They are:—

(1) The melting points of the metals should be substantially different.

(2) Intersolubility of the metals should be non-existent, or as small as possible.

(3) No intermediate high melting point phases should form which could interfere with the progress of infiltration.

(4) Adequate wetting of the skeleton by the infiltrant must be ensured by the use of fully reducing conditions.

(5) Where some intersolubility does exist, it is desirable to use infiltrants, in particular, of equilibrium composition.

(6) Time and temperature should be limited to reduce solubility effects generally to a minimum.

These conditions can only be satisfied by a limited number of combinations of metals, and two such combinations are now of industrial importance. They are tungsten-copper, used in the manufacture of electrical contacts, and iron-copper, which will be considered in some detail.

The alloy diagram of the iron-copper system (Fig. 6) meets the basic requirements for infiltration; the melting points of copper and iron are significantly different, intersolubility is limited, and no intermediate phases of high melting point exist. Both metals are easily maintained in the reduced condition, and wettability of the skeleton by the infiltrant is thereby ensured.

The interest of the infiltration technique lies in the possibility of making a solid material by the powder metal process. In the normal course of events, porosity in sintered compacts can be eliminated by the use of extra energy, e.g. coining. The infiltration technique, however, can achieve infilling of the voids of a porous skeleton and, therefore, removes the main source of weakness of porous compacts.

It will be appreciated that only intercommunicating pores can be filled by the infiltration process and it is, therefore, an essential part of the technique to manufacture porous skeletons with the highest degree of interconnected voids. High density skeletons are, therefore, not necessarily desirable.

The microstructure of infiltrated material (Fig. 8) illustrates the degree of solidification which is achieved, but also demonstrates that a few small pores remain unfilled. Some are evidently blind pores into which the infiltrant cannot penetrate.

The manufacture of infiltrated material involves three stages, i.e. compacting and sintering of the skeleton, followed by infiltration. The skeleton is normally an iron compact, containing about 20-30 per cent porosity, the sintering of which may be adequately carried out at temperatures up to 1,150°C.

In the infiltration stage, a controlled amount of the copper infiltrant is placed in contact with the iron skeleton and both are passed through a suitable furnace under reducing conditions. It is important that the amount of the infiltrant be accurately related to the available porosity of the skeleton. On the one hand, it is undesirable to have an excess of copper, since this will remain on the outside of the infiltrated compact and will detract from the surface quality and the dimensional precision; on the other hand, if too little infiltrant is present, the full potential properties of the infiltrated compact will not be developed.

The relative positions of the infiltrant and skeleton are not too critical, since the surface tensional forces which bring about infiltration are far stronger than the force of gravity. For instance, no difficulty is encountered if the infiltrant is placed beneath the skeleton and the movement of liquid metal is against gravitational forces.

The temperature of the infiltration cycle must, of course, exceed 1,094°C., the temperature at which alpha copper melts. Once the skeleton reaches this temperature and the infiltrant is fully molten, the actual infiltration process is rapid and takes no more than a period of seconds. Nickel-chrome conveyor furnaces, using exothermic gas, are adequate, and rates of production can be reasonably high.

If pure copper is used as the infiltrant, serious erosion of the iron skeleton is common in the area of entry of the infiltrant. The erosion involves a localized removal of iron and could be serious enough to limit commercial acceptance of the product.

Erosion is due to the solution of iron in copper, and the iron-copper alloy diagram indicates that a limited solubility exists. At 1,094°C., approximately 2·5 per cent of iron can be dissolved in copper.

If an infiltrant containing the equilibrium amount of iron is used, the erosion phenomenon does not arise. This condition is achieved only if the iron is fully alloyed with the copper and it is impossible, for instance, to attain the same result using a mixture of copper and iron powders only, unless fully pre-alloyed.

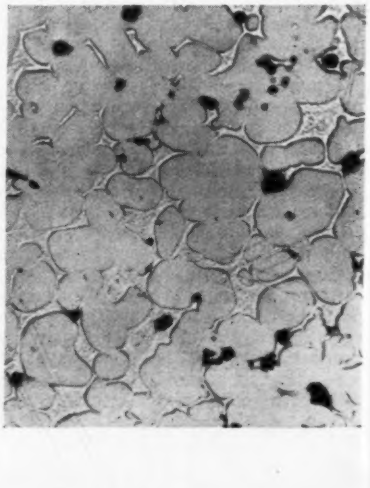
The mechanical properties of infiltrated iron are substantially better than the corresponding porous material, and tensile strengths of the order of 50,000 lb/in^2, and elongations in the range 5 to 10 per cent are normally achieved. The corresponding properties of the skeleton would be 15,000-20,000 lb/in^2 and 3 per cent.

Case carburizing treatments may be applied to infiltrated material, although the diffusion rates appear to be lower than for steel, and longer carburizing times are required. Electroplating is also a proposition, since the normal problems associated with porous metal are not encountered.

One interesting aspect of infiltrated material is that it has a self-brazing property, i.e. the copper can be used as a source of brazing metal. It is possible, therefore, to build up separate components into a more complicated shape by this means.

The temperature limitation of nickel-chrome furnaces prevents the development of high-strength iron powder compacts; on the one hand, there is a limit to the level of properties which can be developed with straight iron material and, on the other hand, the manufacture of iron alloy material is limited, except in some special cases, by the slow rate of alloying which operates at these temperatures. Very

Fig. 8—Copper infiltrated iron (×400)



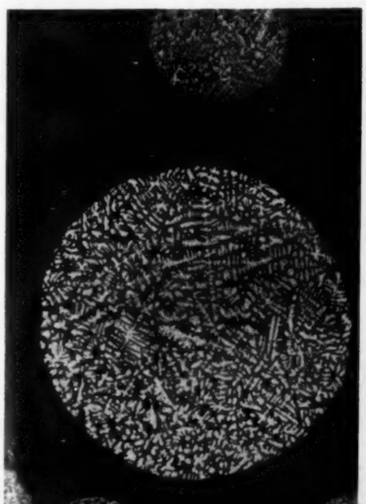
long time sintering treatments would be necessary. The various disadvantages of using pre-alloyed iron powders have been mentioned, but, in any case, the degree of sintering would be limited by the temperature conditions. The iron-copper alloys are, of course, to be regarded as a special case owing to the liquid phase conditions which it is possible to create during sintering.

The demand for higher strength sintered materials in recent years has emphasized the merits of higher sintering temperatures, whereby it would be possible to develop higher degrees of sintering and, therefore, to achieve better mechanical properties. In addition, the use of higher sintering temperatures permits more rapid alloying and allows the manufacture of alloy materials from mixed powders, rather than from pre-alloyed powders. The high temperature sintering field includes temperatures up to 1,400°C.

Progress in the field of high temperature sintered materials has been limited by the availability of suitable production sintering equipment. Batch type furnaces have been available for a number of years, but the development of a continuous production furnace, capable of sintering up to 1,400°C. at relatively high rates of production, has come about only in recent years. The most suitable furnace is of the molybdenum type, in which the protective atmosphere for the elements can be combined with the sintering atmosphere for the work. A hydrogen or cracked ammonia atmosphere is most suitable for this purpose.

Materials so far developed in the high temperature sintering field include stainless steels and iron alloys, mainly alloys of iron and nickel. The stainless steel materials are usually based upon pre-alloyed powder, since special difficulties, connected with the problem of maintaining chromium in the fully-reduced condition, arise with mixes containing this metal. Unless reducing conditions are achieved, alloying is retarded.

Fig. 9—Pre-alloyed spherical bronze powder (×*200*)



The iron-nickel alloys so far developed include nickel up to a level of about 5 per cent. For this type of alloy it is best to employ a mixture of iron and nickel powders, and to bring about alloying during sintering. In order to enhance the homogeneity of the compact, it is desirable to use as fine a nickel powder as possible, and carbonyl powder is most useful in this respect. Sintering times of the order of 1 hr. at 1,350°C. to 1,400°C. are necessary to achieve a useful degree of alloying.

The iron-nickel alloys are manufactured to a reasonably high density, usually of the order of 7 gm/c.c., and the mechanical properties are substantial. Tensile strengths of 60,000 lb/in^2 or more are achieved, and elongations between 5 and 10 per cent are normal.

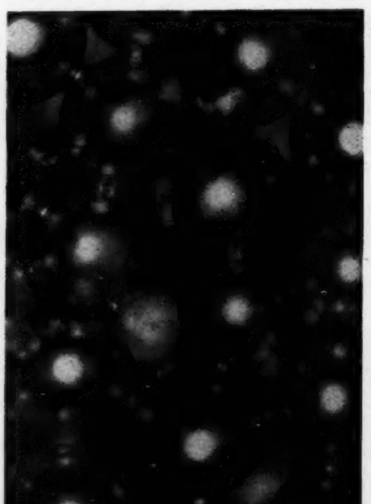
The manufacture of high strength structural materials by high temperature sintering techniques opens up a very wide field for powder metallurgy components, and this sphere of powder metallurgy is sure to develop further in the future.

Sintered Filters

Sintered metal filters belong to the class of unique products of the field of powder metallurgy.

The basic attraction of a sintered metal filter lies in the ability of the powder metal technique to manufacture a porous article of controlled properties, combined with a useful level of mechanical strength. For instance, by special control of the raw material it is possible to produce a range of filters that have well controlled filtering and flow properties. Furthermore, mechanical properties can be developed that compare favourably with other types of filter media, e.g. ceramic or mesh materials.

Fig. 10—Sintered bronze filter (×*80*)



The applications of sintered metal filters include the filtration of oils, petroleum liquids, water, and various other chemical liquids. Probably the outstanding merit is the ability to remove relatively fine particles of a controlled size.

The applications for metal filters primarily call for good corrosion resistance, and the materials that are so far offered have this characteristic; 89:11 bronze, 18:8 stainless steel, Monel and nickel filters are of greatest interest, and the first two are now established in production.

High porosity is most desirable in sintered filters in order to confer best flow characteristics, and compacting of the powder is not an attractive method of manufacture for this reason. In fact, the sintering of loose powder is the most suitable technique to give highest porosity.

With regard to the choice of material, a spherical powder particle shape is most desirable from the point of view of best flow properties, consistent with the ability to filter out the lowest possible particle size. In addition, the various considerations which relate to the choice of powder for the manufacture of sintered bronze bearings are not so applicable to filters. For instance, no compacting operations are involved and the disadvantage, in this way, of pre-alloyed powder does not apply. These various considerations dictate that the best way to manufacture porous filters is by a loose powder sintering process, based upon pre-alloyed spherical powder.

Control of the properties of flow and filtering performance is achieved by sieving the raw powder into various particle sizes. A fine powder will produce a low permeability filter, and the particle size of the solids removed from suspension will be very small. On the other hand, a coarse powder will produce a filter having high flow characteristics, and the particle size of the filtered particles will be correspondingly greater.

The microstructure of spherical bronze powder (Fig. 9) demonstrates the high degree of sphericity, and the internal structure resembles that of a cast bronze alloy. A typical cored structure is evident.

The manufacture of filters primarily involves the assembly of the powder in a suitable mould, followed by sintering of the shape so produced. The mould, of course, suffers a similar heat-treatment cycle and is used again. An exothermic atmosphere is normally adequate to maintain reducing conditions.

The sintering of pre-alloyed powder takes place in the absence of any liquid

phase and is a function of both time and temperature, the higher the temperature, the shorter the time, and vice versa. Higher sintering temperatures, therefore, permit faster production, but the sintering cycle becomes more critical under these conditions and, in practice, a compromise is necessary.

The macrostructure of a sintered bronze filter (Fig. 10) shows the fillet welds which develop between the spherical powder particles. Such fillets are, of course, the normal form of bridging which would be expected to develop under the action of surface tensional forces.

The mechanical properties of bronze filters are relatively low, due to the high degree of porosity. The porosity and density are of the order of 30-40 per cent and 5-6 gm/c.c. respectively. Nevertheless, the mechanical strength of sintered filters compares favourably with other types of filter, and tensile strengths are of the order of 5,000 to 10,000 lb/in^2.

The physical properties of the filters can be varied over a wide range: the size of the filtered particle may be as low as 2 microns and may be as large as 50-100 microns. The flow characteristics vary over a wide range according to the grading.

The manufacture of stainless steel filters basically differs from that of bronze in two respects, i.e. sintering temperature and atmosphere. Both temperature and the quality of the atmosphere must be of a high order.

The melting point of 18:8 stainless steel is 1,400°C., and sintering temperatures approaching 1,300°C. are necessary to develop useful levels of strength within reasonably short periods of time. Sintering atmospheres are those which are suitable for the bright heat-treatment of stainless steel, and include pure hydrogen, cracked ammonia, and vacuum.

The development of stainless steel filters has been limited by the same considerations which were relevant to the production of high temperature structural materials, i.e. the availability of suitable production equipment, capable of uniformly heat-treating work at a reasonable rate of production. For these reasons, sintered stainless steel filters have become commercial products only in the last few years in both Europe and North America.

The mechanical properties of stainless steel lie in general proportion to those for bronze. Densities are of the order of 5 gm/c.c. and porosity is of the 40 per cent level. Tensile strengths in the range of 15,000 lb/in^2 are normal.

Spectroscopic Analysis

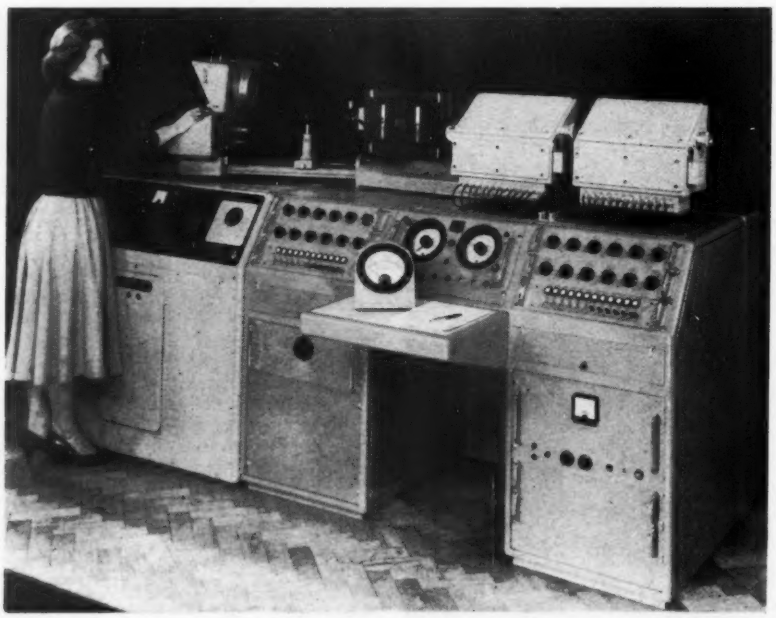
A PHOTOGRAPHIC and direct-reading spectrograph combined, that will do all the work for which two instruments have hitherto been required, has been added by Hilger and Watts Limited, 98 St. Pancras Way, Camden Road, London, N.W.1, to their range of spectrographs. This instrument will, therefore, be of particular use in laboratories where there is a large amount of routine work to be done, but where there are also some qualitative and quantitative analyses that fall outside the scope of the direct-reader.

As its name implies, the Hilger triple medium spectrograph has three measuring heads. One of these is for photographic analysis and can be used for the same type of work as the well-known Hilger medium quartz spectrograph. The other two measuring heads can be set up for the automatic analysis of non-ferrous metals, oils, soil, and similar materials. The spectrum required is chosen by switching mirrors.

Each direct-reading head accommodates 12 photomultipliers, and will give quantitative analysis of up to 11 elements in about 2 min. These direct-reading heads can be set up for two completely different analyses (e.g. aluminium and magnesium alloys) or for the analysis of two different groups of elements in the same alloy (e.g. minor constituents and trace elements). For the latter application it is normal to use two separate sparkings—one for the minor elements, using one bank of photomultipliers, and the other for trace elements, using the other bank of photomultipliers, though in certain restricted circumstances it is possible to analyse up to 22 elements with one sparking.

It is not necessary to order both direct-reading heads at the same time. The instrument can be supplied in the first place with only one of these attachments, and the second can be fitted at a later date, when required.

The Hilger triple medium spectrograph



Tin-Lead Solders

IN cyclic loading tests carried out at Battelle Institute, and reported by the Tin Research Institute, into the strengths of tin-lead solders, the life of boxes made with 70 tin:30 lead solder was three times that of those made with 30 tin:70 lead solder. This improvement, which is clearly due to the use of a richer tin solder, was even more marked when cerium was present. The 70 tin:30 lead solder with cerium was then roughly six times as long-lasting as the 30 tin:70 lead with cerium. Further increases in the cerium content were all proportionally less beneficial and the optimum range was between 0·05 and 0·10 per cent. The tin content of tin-lead solders in the United States for the soldering of motor car radiators is seldom higher than 40 per cent, but these tests suggest that a three-fold improvement in the life of radiators under cyclic loading could follow from using a solder containing 70 per cent or more of tin, and a five- or six-fold improvement could result from adding the right proportion of cerium.

Industrial News *Home and Overseas*

Aluminium at London Airport

Since most of the routine checks and maintenance required by to-day's airliners are carried out on the forward part of the machine, and since economy of operation is as important in air transport as in any other business, British Overseas Airways Corporation have recently introduced the "wing hangar" at London Airport. This development, which is new to Britain, encloses only the forward portion of each aircraft, leaving the whole of the tail unit protruding, thus economizing on hangar space and the cost of building. By having sliding doors recessed to embrace the fuselage, the hangar can be completely enclosed while work on the aircraft proceeds.

The doors themselves are of interesting design and provide an unusual example of metal fabrication. There are 48 altogether, 24 on each side of the hangar, which is bisected by a central dividing service hall; 10 of the 24 are motorized, and six are made with a suitable aperture for the tail enclosure unit.

Each door is 32 ft. high, 23 ft. 6 in. wide and 1 ft. thick, and is provided with generous windows; a wicket door is provided in each of the motorized doors. The doors forming the tail enclosure units are fitted with flexible fabric gaskets to seal the gap between the doors and the fuselage and yet permit the aircraft a fair degree of movement during servicing. When these units are not in use the apertures can be closed by hinged flaps.

The guide wheels run in brackets fitted to the top of the door frame, and the main wheels are housed in a fabricated chassis forming an integral part of the frame. The chassis of the motorized doors is strengthened to carry a 2 h.p. electrical power unit, fluid drive, and clutch mechanism.

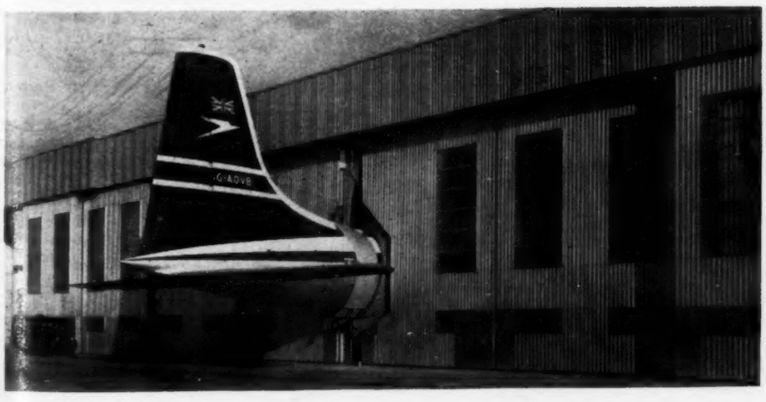
The framework of each door is constructed of steel channel section, 12 in. $\times 3\frac{1}{4}$ in $\times$ 10 S.W.G., cross-braced with a similar section having lightening holes to reduce weight, and use is also made of lattice-type members. The whole was electrically welded. To facilitate handling, the framework was constructed in three sections, which were bolted together using gusset plates slotted through the main channels.

Cladding is of aluminium: Noral Mansard sheet, 0·036 in. and 0·028 in. thick (20 and 22 S.W.G.) is secured to both sides of the framework by "pop" rivets, and an extruded "top-hat" section in Noral B51SWP alloy is used to cover the bolt heads so as to give a neat finish. To prevent reaction between the steel and the aluminium, the framework was given phosphate treatment followed by a zinc chromate dip, and, in addition, the aluminium surfaces that were to make contact with the steel were coated with a bituminous paint.

Aluminium, in the form of flat sheet in Noral 3S alloy, half-hard, in thicknesses ranging from 0·064 in. (16 S.W.G.) to 0·125 in., was also used for cladding the wicket doors and the hinged flaps that cover the fuselage aperture when required.

It is estimated that the assembly of each door required altogether about 450 ft. of welding, which was used not only for the main framework but also for the attachment of glazing bars, cladding stiffeners and other parts. Altogether, some 24 tons of aluminium, averaging about half-a-ton for each door, were supplied by **Northern Aluminium Company Limited.**

Doors of new wing hangar at London Airport



A "Wiggin" Exhibition

Widespread publicity was given to the prestige exhibition which was held this week at the Town Hall, Hereford, in order to present to the citizens of Hereford how the products of **Henry Wiggin and Company Limited** contribute to world industry and to the amenities of their everyday life. The exhibition was opened by the Mayor of Hereford and remained open all the week.

Industrial Films

At a recent meeting of the Midland branch of the **Institution of Engineering Designers** in Birmingham, members saw two films on "The Flame Hardening Process" and "Advances in Oxy-Acetylene Welding Techniques." These films were provided by British Oxygen Gases Ltd., and a representative of the company answered questions after the films had been shown. Both films are obtainable on loan from the Sales Technical Service Department of the company at North Circular Road, London, N.W.2.

Scientific Instruments

A number of new instruments have recently been introduced by **Short and Mason Ltd.,** including the Drage multi-test unit. This device is a "multi-test" tensile, compression or bending, testing machine, and is stated to be a most versatile instrument. Measuring heads from 0·5 g. to 50,000 kg. are available, and a strip chart recorder is provided having two pens which can be connected so that two functions can be simultaneously plotted with respect to a third function (e.g. extension and load against time). The sample under test may be subjected to deformation, oscillating loads, or held under a constant load. All the controls are mounted on a convenient panel and the machine is protected by interlocks and safety devices.

Aluminium Maintenance Platform

A specially-built aluminium alloy maintenance platform, produced by **Lyte Ladders Ltd.** to the specific requirements of the Bristol Aeroplane Company Ltd. is being used by the aircraft company in the construction and maintenance of their "Sycamore" and 192 helicopters.

The platform, which is easily transportable, light, rust-proof and very strong, is constructed so that it spans the projecting axle of the helicopter and allows the technician to work as closely as he pleases to the body of the machine.

Factory Reorganization

Growing industrial demand for reliable instruments capable of measuring low resistance in electrical equipment to a high degree of accuracy, has made it necessary for **Evershed and Vignoles Limited** to re-organize part of their factory for the purpose of increasing the production of the Ducter "Low Resistance Testing Set," which is a direct-reading instrument measuring low resistances of a few ohms down to 1 microhm.

Lightweight Aluminium Urn

Among the many applications of aluminium is an aluminium urn for holding cremation ashes during transport. It is also suitable for storing ashes. Previously, ashes have been conveyed in waxed-paper cartons. These urns, made by **Victoria Metal Spinning Ltd.,** of Leeds, 10, are of Noral 2S alloy, fitted with an air-tight screw lid that may be locked in position by linking a piece of wire, which also carries an identification tag, through an eyelet on the lid and another on the body of the urn. A snap-fit cover goes over the top of the screw-lid and so completes the neat profile.

Copper Smelter for Chile

A group of West German firms, headed by Kloeckner Industrieanlagen, of Duisburg, has received an order from the Chilean Empresa Nacional de Fundiciones for the construction of a copper smelting plant in Chile. Other members of the group are Kloeckner-Humboldt-Deutz, of Cologne, Demag Elektrometallurgie of Duisburg, and Siemens-Schuckert of Munich/Berlin.

In the initial stage the plant would have a productive capacity of about 30,000 tons of blister copper annually. Its processing capacity would be about 180,000 tons a year. It was planned to expand the plant's capacity to 80,000 tons of blister copper a year, and the processing capacity to about 450,000 tons

annually. It was also intended to increase the production installations by adding an electrolytic plant and facilities for the production of copper sulphate.

Soviet Non-Ferrous Metals

Found mainly in the Urals near Sverdlovk and Chkalov, and in the Murmansk peninsula at Pecheny and Monchegorsk, some 77 per cent of known Soviet nickel ore deposits are sulphides and 23 per cent are silicates, according to Soviet reports. The silicate ores tend to have a higher nickel content than the sulphides. Nickel yield from silicates accounts for 36 per cent of total nickel production, while extraction from sulphides accounts for 64 per cent.

Tin-bearing ore is found in Yakutia (Siberia), in Kazakhstan, and in the Novosibirsk region. The metal is extracted from sulphides, quartz with veins of tin, and from pegmatites. Ore production and metal extraction figures are as follows (in per cent of the total): sulphides 80 ore production, 95·5 metal extracted; quartz 19 ore production, 4·0 metal extracted: pegmatites 1 ore production, 0·5 metal extracted.

The Soviet Union, it is claimed, is the world's second largest wolfram producer, with China holding first place. The wolfram content of Soviet ores, however, is low, and, therefore, there is an enrichment problem which has not been solved to full satisfaction so far. Until such a solution is found costs of wolfram extraction will remain high.

There are a number of large bauxite deposits supplying the aluminium smelters. The main deposits are located in the Urals, in Central Kazakhstan, in the Vologda and Leningrad districts of European Russia, in the Ukraine, in Western Siberia, and in the Krasnoyarsk district of Eastern Siberia. Attempts are also being made to exploit other aluminium-bearing minerals, such as nephelites, which have been found in the Murmansk peninsula, and alunites and andalusites, which have been discovered in Azerbaidzhan. According to the latest issue of the Soviet mining journal, a method for extraction of aluminium from nephelite has been developed and is already being used.

Group Activities

One of the aspects of public relations that has become of tremendous importance during the post-war years is that which is concerned with showing the world the services offered by a company or group, and emphasizing the ramifications of the various associate companies or subsidiaries which work together in a co-operative undertaking. One way of doing this is by means of descriptive literature, and a first-rate example of this is a booklet issued by **Engelhard Industries Ltd.** This gives a view of the various companies, their products and their achievements, and it is a fine production.

Notable among the many concerns within the group are, of course, those operating in Great Britain, i.e. the Baker Platinum Division, the Hanovia Lamp Division, and Hanovia Products Ceramic Division, all of London.

Long Service Awards

This year a record number of 624 employees of the Metals Division of **Imperial Chemical Industries Limited** qualify for long service awards, 50 of them having served the company for 40 years, 173 for 30 years, and 401 for 20 years. The awards were presented at the close of a dinner to which recipients and their wives were invited. The company feels it is appropriate that a member of the employee's family should be present when the company makes official acknowledgment of its appreciation of long and loyal service. Eleven such dinners are being held in Metals Division this year, the smaller gatherings making it possible for celebration and congratulation to be conducted on a more friendly, informal basis than could be achieved at one large function.

Long service award dinner of Imperial Chemical Industries Limited

In the photograph shown on this page, taken at the dinner which was held recently, the Division chairman, Dr. Maurice Cook, is standing in the centre of the group at the top table. On his right is Mrs. Banks, standing next to her husband—Mr. R. A. Banks, personnel director on the main board of I.C.I. Seven Metals Division directors were also present, and recipients on this occasion were members of Metals Division Headquarters, Lightning Fasteners Limited, and Summerfield Research Station.

A Presidential Visit

On Thursday of last week, a large gathering of members and students of the **Institution of Metallurgists** attended the College of Technology, Birmingham, to hear the President of the Institution, Mr. J. Mitchell, C.B.E., give an address on "The Functions of a Professional Institution." The chair was taken by Dr. E. G. West, hon. treasurer of the institution.

The meeting, which was preceded by a meal, was another of the series of regional meetings which it is now becoming the practice of the President to hold in various parts of the country. His address was followed by a general discussion. In the course of his address, Mr. Mitchell referred to a discussion which had taken place between the officers of the institute on a recent editorial in METAL INDUSTRY on the shortage of scientists. His own view was that much of the shortage as far as metallurgists were concerned was created by the use of qualified metallurgists in positions which were often well below their professional capabilities.

Copper Stabilization

It is reported from Santiago that Chile has proposed to the International Trade Commission of the United Nations the creation of an international body to prevent sharp fluctuations in world prices of copper. The United Nations Commission meets in New York on May 5 and the meeting is expected to continue until May 16. The initiative for the proposal came from the Chilean Foreign Office, which some weeks ago, at the request of the Copper Department, issued instructions to the Chilean delegation at the United Nations.

Meanwhile, Senor Javier Lagarrigue, the Economic Counsellor of the Chilean Copper Department, is now in the United States on his way to London for the copper producers' meeting on May 8.

Literature on Nickel

Literature abstracted in the Electrodeposition Section of the March issue of *The Nickel Bulletin* includes a report of a fundamental study of factors involved in electroless plating. Other items in this section include a description of an electrolytic + diffusion process for nickel-plating of aluminium, and a report on the relative efficacy of the acetic acid-salt spray and the sulphur dioxide accelerated corrosion tests.

Reference is also made to the use of nickel-aluminium bronze for marine propellers and pumps, and to the fracture properties of copper alloys, while other items of particular interest include comprehensive Papers on vacuum melting of high-temperature alloys, high nickel alloy spring materials, and nickel-containing brazing alloys.

The Bulletin is issued by **The Mond Nickel Company Limited,** Thames House, Millbank, London, S.W.1.

U.K. Metal Stocks

Stocks of refined tin in London Metal Exchange official warehouses at the end of last week totalled 17,698 tons, comprising London 5,790, Liverpool 10,788, and Hull 1,120 tons. Copper stocks totalled 19,432 tons, and comprised London 11,334, Liverpool 6,983, Birmingham 915, Manchester nil, Swansea 175, and Hull 25 tons.

Aluminium Foil in Australia

A British and Canadian group are to build an £A1,000,000 factory in Sydney to produce aluminium foil. The group is Aluminium Limited, and British Aluminium Company Limited, London. The companies own Australian Aluminium Company Pty. Limited. Aluminium Foils (Australia) Pty. Limited, a wholly-owned subsidiary of Australian Aluminium, will operate the new mill.

It is expected that production will start

within 18 months and will be 1,500 tons a year initially. A spokesman for the British and Canadian companies said that the new mill would be the only aluminium foil mill in Australia to produce a full range of products for the tobacco, confectionery, radio and packaging industries.

Sarawak Bauxite

It was stated in Semantan (Sarawak) recently by Mr. Charles Schwander, technical director of Semantan Bauxite Ltd., that Sarawak will soon start exporting bauxite from the town of Semantan. He said the first shipment of 6,000 tons of ore would go to Formosa shortly. This was part of an order for 50,000 tons. Mr. Schwander said production from the Semantan deposits would be raised to 33,000 tons a month. The ore would be shipped principally to Formosa and Japan.

Electrode Holders

We understand from **Rediweld-Oerlikon Electrodes Ltd** that the company now has a range of eight different types of electrode-holder, from 200 to 600 amp., all fully insulated. These are reasonably priced, from 25s. to 69s., and there are various discount rates for quantities.

Barrier Cream Dispenser

Used widely in factories and workshops of all types, the Rozalex dispenser has now been modified to provide additional cleanliness and ease of maintenance. This modified dispenser, developed by **Rozalex Ltd.,** is entirely chromium plated, inside and out, holds 2 lb. of any Rozalex barrier cream, which is sufficient for 150 to 200 normal applications. Incorporated in the lid is a locking device with a removable key, to prevent misuse.

Sole Agency

We are informed by **Newman Industries Limited** that they have been appointed sole selling agents in this country for all heavy Hungarian machine tools. Machines already imported by the company include centre lathes, radial drills and milling machines. A unique range of heavy milling machines is stated to have just arrived at the company's Bristol showrooms.

Metal Finishing

On Thursday of next week (May 1), the annual general meeting of the North-West branch of the **Institute of Metal Finishing** will be held at 7.30 p.m. at the Engineers' Club, Albert Square, Manchester. At the conclusion of the general meeting a Platers' Forum will be held.

A Birmingham Demonstration

Advance notice is given of a special demonstration week which has been arranged by **Roto-Finish Ltd.,** to be held at the Birmingham Exchange and Engineering Centre from May 12 to 15 next. The firm will be exhibiting several of their machines, as well as their processes for descaling, deburring, radiusing, brite-honing, colouring, blending, smoothing, and cutting down.

Industrial Safety Award

First presented in 1956, the Sir George Earle Trophy for industrial safety has this year been awarded to **Imperial Chemical Industries Ltd.,** "in recognition of the far-sighted policy of its board and its attitude towards the problems of industrial accident prevention, and of the altruistic and generous way in which the extensive safety knowledge accumulated within its own organization has been made available continuously to industry throughout the world."

This is the third time the trophy has been awarded. In 1956, the recipients were H.M. Inspectors of Factories and last year it was awarded to the Birmingham and District Industrial Safety Group. The President of the Royal Society for the Prevention of Accidents will present the trophy, together with a commemorative plaque, at the society's National Industial Safety Conference, which will take place at Scarborough next month.

Open Days

This year's "Open Days" at the **National Physical Laboratory** are fixed for Wednesday and Thursday, May 14 and 15, and there will be about 200 exhibits of N.P.L. work on display, and visitors will have the opportunity of discussing these, and other items of work not on show, with the staff at the Laboratory.

New Appointments

It has been announced that Mr. C. A. Flint has been appointed secretary of **Sparklets Limited,** and Mr. J. B. Shott appointed as chief accountant of the company.

Sales Promotion

Senior representative of the **Firth Company Ltd.,** Mr. E. W. Nicholls has left by air for a six weeks' visit to Canada and the United States in connection with the company's export sales promotion plans in those two countries.

Special Tin Fund

It was announced in London this week by the International Tin Council that contributions to its special fund had now been received by the Buffer Stock Manager. The Council agreed at its January meeting that delegates of the producing countries should recommend their Governments to create this special fund for the disposal of the Buffer Stock.

The Council also announced that the second subsequent contribution to the Buffer Stock, which was called for at the end of last December, had now been fully paid to the Buffer Stock Manager by the participating producing countries. This contribution, equivalent to 5,000 tons of tin, became due when the Buffer Stock held 15,000 tons.

Parliamentary News

By Our Lobby Correspondent

Trade with China.—At Question Time in the Lords, Viscount Elibank asked the Government whether their attention had been drawn to the sale of 20,000 tons of copper wire by Chile to Russia, and whether they had any information to show that there had also been sales to China.

For the Government, Lord Mancroft replied that the Chilean Copper Department announced on March 19 that contracts had been placed for the export of approximately 16,000 tons of copper wire in 1958 from Chile to what were described as "the Eastern countries." It was understood that the total included about 10,500 tons of copper wire for the Soviet Union and 300 tons for China.

Viscount Elibank then asked whether the Minister was aware of the variation between the quantity and the strategic controls, and that because of doubts as to receiving export licences, manufacturers and exporters of copper products in this country found it extremely difficult to formulate their plans ahead.

Replying in the affirmative, Lord Mancroft said there was considerable difficulty. But any exporters and manufacturers who were thinking of entering that market would be well advised to consult the Board of Trade well ahead so that they could make their plans. The Board of Trade were more than ready to offer any assistance they could.

Viscount Elibank said that the Government's policy in the review of the controls was to confine control to goods which were still of strategic importance. He asked on what information the Government decided what was the critical level of exports before they became strategic.

Lord Mancroft replied that the criteria which governed the decisions were confidential and had never been released by the Paris Group.

Viscount Stansgate said it was about time that this farce came to an end. Year after year they were told that the matter was being looked at and was confidential. Were the Government prepared to suggest to the appropriate authority a fundamental review of the whole policy of the blockade to China?

Lord Mancroft replied that the whole matter was before the appropriate authority.

Lord Henderson: "Will the Government bring a definite proposal before the appropriate authority that it is time to stop this embargo on trade to China?"

Lord Mancroft: "All these difficulties are being thrashed out. But we do not act alone on this matter. We have allies to consult and convince."

Viscount Stansgate: "And in the meantime Chile sends as much copper as she wishes for strategic or other purposes to the Soviet Union."

Lord Mancroft: "But she is not a member of the Consultative Group."

Earl Attlee: "Is it not about time that we stood up to the United States on this question?"

There was no reply.

Forthcoming Meetings

April 28—Institute of Metals. Church House, Great Smith Street, London, S.W.1. Golden Jubilee Meeting.

April 29 — North East Metallurgical Society. Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough. Annual General Meeting. 7.15 p.m.

May 1 — Leeds Metallurgical Society. Lecture Room "C," Chemistry Wing, The University, Leeds, 2. Annual General Meeting, followed by "Chromising." M. L. Becker. 7.15 p.m.

May 1 — Southampton Metallurgical Society. The University, Southampton. "Modern Metallographic Techniques." M. A. Haughton. 7.15 p.m.

May 1 — Institute of Metal Finishing. North-West Branch. Engineers' Club, Albert Square, Manchester. Annual General Meeting, followed by Platers' Forum. 7.30 p.m.

Metal Market News

TRADING last week on the London Metal Exchange seemed still to be under the influence of the Easter holidays, for interest was lacking and the turnovers hardly up to average. At this time of the year there is nothing unusual in that, and maybe April will turn out to be rather a poor month. The Budget would not seem to have had any effect on sentiment and, in any case, there was not much in the Chancellor's statement to influence the trend of non-ferrous values. On the Stock Exchange, business was not brisk but quotations were steady, and advances were registered in some industrial shares. In the States, Wall Street had its ups and downs but, broadly speaking, the movement of shares in New York is contrary to developments in the country at large, for industrial activity seems still to be declining, and in business circles optimism is not much in evidence. So far as copper is concerned, the price structure remained unaltered, with custom smelters at 23½ cents and the producers at 25 cents. It would not appear that there is much going on, and a drop back to 23 cents by the smelters cannot be easily dismissed. The March copper statistics issued by the Copper Institute showed that conditions in the States are still very poor, for there was a decline in deliveries to consumers to less than 90,000 short tons, the lowest seen for a great many years. Stocks rose sharply, and all in all it was a very poor showing. Outside the United States, however, a marked improvement on February was seen, even though it had not been thought that, so far as the U.K. was concerned, last month was not particularly good. It is generally accepted that in the semis industry things are not what they were, and it rather seems as though the summer months will see a lower rate of usage than is being seen to-day.

In copper, there was a decline of 125 tons in L.M.E. stocks in warehouse to 19,532 tons, but this must be considered to be a good figure, even though a fairly high proportion of the warrants are believed to be held in a few hands. Fortunately, the contango is quite well established, which is no little encouragement to those who wish to use the market for hedging. The turnover on the standard market was about average and amounted to 8,825 tons. On balance, price changes amounted to a rise of £3 15s. 0d. in cash and of £3 5s. 0d. in three months. The copper market certainly seems to have got into a somewhat stagnant mood, and values vary relatively little from day to day. This means that there is little incentive to consumers to place business and they are, therefore, more than ever inclined to sit on the fence and reduce their buying to a minimum. Possibly there never was a time when consumers of copper were so wedded to the idea of hand-to-mouth buying, for not even the Chuquicamata strike has persuaded them to abandon this ultra-cautious attitude.

However, on Friday came news that Kennecott has decided to cut output again, this time by 3,350 tons per month, this being additional to 7,500 tons monthly already announced. Compared with last year, the rate of operation will be no more than 67 per cent. Whether this indication of intention to meet the menace of the lower American demand will persuade buyers here to abandon their present cautious attitude remains to be seen. Tin also ended the week on a firm note, in sympathy with copper and in view of the lower shipments from the East. Both cash and three months were quoted £731 10s. 0d., the former being up £1 and the latter £2 10s. 0d. The turnover was 910 tons. Zinc and lead put up a fairly good show, optimism being based on the hope that the State Department may decide after all to renew their stockpiling activities. Lead closed at £73 both positions, April gaining 10s. and July 7s. 6d. Zinc was quoted at £62 12s. 6d. for April and £62 15s. 0d. July, these prices registering gains of 17s. 6d. and 10s. for the respective positions.

Birmingham

Although unemployment in the Midland area has risen by about 1,000 in a month, the percentage is still only 1·4, compared with 2 per cent for the country as a whole. Short-time working has also risen by a small amount. At a recent meeting of the Midland Regional Board for Industry it was stated that Midland industry completed more new factories and extensions in 1957 than in any previous year. The boom in industrial building, however, has now passed, and in the first quarter of this year there were slightly fewer applications to the Board of Trade for industrial development certificates than in the corresponding period of last year—89 against 95. It was also stated that the outstanding performance of the motor industry was making an important impact on the industrial activity of the Midlands.

The motor trade continues to take big supplies of steel sheets and other products. One weak spot is the fall in demand for tubes owing to slackness in the building industry. This trade declined sharply at the beginning of the year and has not yet made any noticeable recovery. Some of the iron foundries are slack because of the dullness of the light castings industry, but there is a steady demand for heavy castings for engineering purposes. The re-rolling steel mills are operating short time, but mills producing heavy plates and structural material continue well booked to the end of the half-year.

New York

Demand for non-ferrous metals here during the week ended April 15 continued slow. Custom smelters marked down their electrolytic copper price by half a cent to 23½ cents per lb. without arousing any noticeable buying interest from fabricators. Producers reported little change in their slow selling conditions, with the March copper statistics indicating continued over-production of copper in the United States.

The trade showed interest in a statement by the Secretary of the Interior, Mr. Fred A. Seaton, to the Senate Finance Committee endorsing the Watkins Bill to revoke the present suspension of duty on copper. However, a spokesman for the Interior Department stressed that the Secretary's support was for the Watkins Bill and did not cover other legislations.

Congressmen who are concerned with the copper industry are reportedly not pleased with the Administration proposal. They favour instead an increase in the so-called peril point of 24 cents a lb. to 30 cents, with the application of a four cents a lb. duty when the price sinks below 30 cents.

The Administration favours the imposition of a duty now, rather than waiting until June 30. The duty which would be imposed if the copper suspension were lifted now would be 1·8 cents a lb., and the July 1, 1·7 cents, if the average price is still above 24 cents.

Lead and zinc activity continued quiet. The prices of high grade and special high grade zinc were lowered. Special high grade zinc was reduced half a cent to 11¼ cents per lb., while the high grade was lowered by 0·35 cents to 11 cents. Prime Western zinc continued at 10 cents per lb.

Depressed automotive and brass mill production were cited as the reasons for the softness in these premium grades.

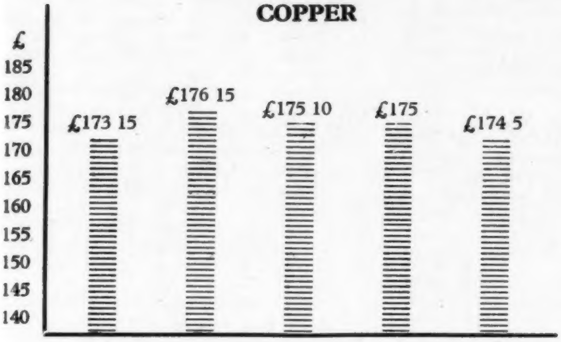
Tin was slightly erratic, with consumer interest lacking and only modest dealer activity noted.

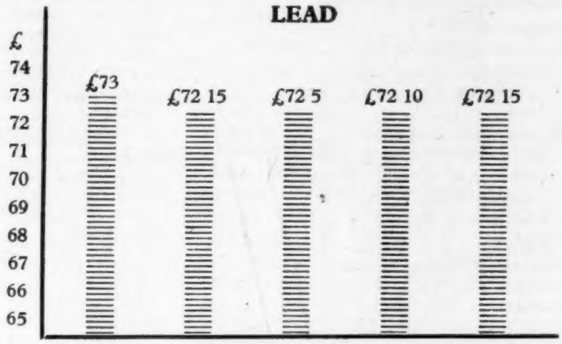
Zurich

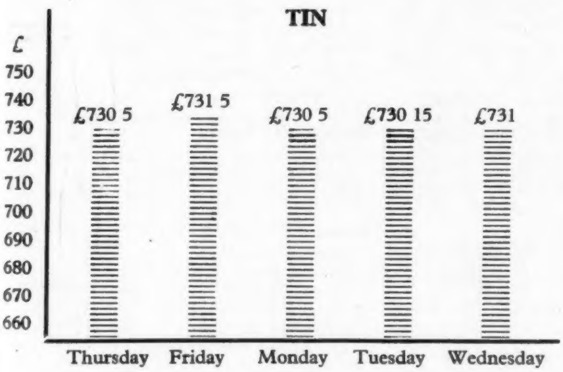
The continued unfavourable outlook for the U.S. economy has been the major factor making for the current stagnation in the Swiss non-ferrous metal market. Apart from a temporary improvement in copper business, turnover in most metals have remained steady at their previous low levels. Consumers continued to buy only to meet immediate requirements.

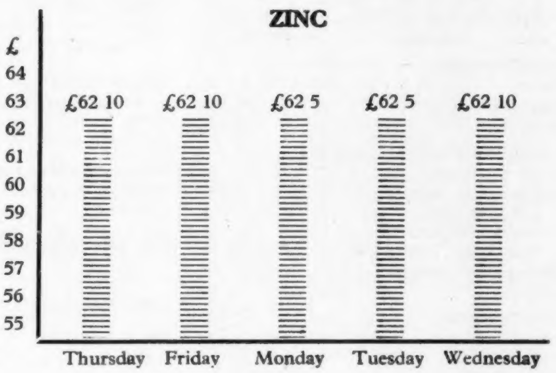
METAL PRICE CHANGES

LONDON METAL EXCHANGE, Thursday 17 April 1958 to Wednesday 23 April 1958









OVERSEAS PRICES

Latest available quotations for non-ferrous metals with approximate sterling equivalents based on current exchange rates

	Belgium		Canada		France		Italy		Switzerland		United States	
	fr/kg ≏	£/ton	c/lb ≏	£/ton	fr/kg ≏	£/ton	lire/kg ≏	£/ton	fr/kg ≏	£/ton	c/lb ≏	£/ton
Aluminium			22.50	185 17 6	210	182 15	375	217 10			26.10	208 17 6
Antimony 99.0					195	169 12 6	430	249 10			29.00	232 0
Cadmium					1,400	1,218 0	2,550	1,479 0			155.00	1,240 0
Copper												
Crude												
Wire bars 99.9							375	217 10				
Electrolytic	24.25	177 5	24.25	200 7 6	223	194 0			2.30	192 7 6	25.00	200 0
Lead			11.25	93 0	114	99 2 6	178	103 5	.93	77 15	12.00	96 0
Magnesium												
Nickel			71.50	590 10	1,060	922 5	1,330	771 10	7.80	652 5	74.00	592 0
Tin	101.00	738 7 6			887	771 12 6	1,410	817 17 6	8.70	727 10	93.00	744 0
Zinc												
Prime western			10.00	82 12 6							10.00	80 0
High grade 99.95			10.60	87 10 0								
High grade 99.99			11.00	90 5								
Thermic					107.12	93 2 6						
Electrolytic					115.12	100 2 6	156	90 10	.82	68 10	11.25	90 0

NON-FERROUS METAL PRICES

(All prices quoted are those available at 12 noon 23/4/58)

PRIMARY METALS

		£	s.	d.
Aluminium Ingots	ton	180	0	0
Antimony 99·6%	„	197	0	0
Antimony Metal 99%	„	190	0	0
Antimony Oxide	„	180	0	0
Antimony Sulphide Lump	„	190	0	0
Antimony Sulphide Black Powder	„	205	0	0
Arsenic	„	400	0	0
Bismuth 99·95%	lb.		16	0
Cadmium 99·9%	„		10	0
Calcium	„	2	0	0
Cerium 99%	„	16	0	0
Chromium	„		6	11
Cobalt	„		16	0
Columbite	per unit		—	
Copper H.C. Electro.	ton	174	5	0
Fire Refined 99·70%	„	173	0	0
Fire Refined 99·50%	„	172	0	0
Copper Sulphate	„	66	0	0
Germanium	grm.		—	
Gold	oz.	12	9	2½
Indium	„		10	0
Iridium	„	26	0	0
Lanthanum	grm.		15	0
Lead English	ton	72	15	0
Magnesium Ingots	lb.		2	5½
Notched Bar	„		2	10½
Powder Grade 4	„		6	3
Alloy Ingot, A8 or AZ91	„		2	8
Manganese Metal	ton	300	0	0
Mercury	flask	77	0	0
Molybdenum	lb.	1	10	0
Nickel	ton	600	0	0
F. Shot	lb.		5	5
F. Ingot	„		5	6
Osmium	oz.		nom.	
Osmiridium	„		nom.	
Palladium	„	7	10	0
Platinum	„	26	15	0
Rhodium	„	40	0	0
Ruthenium	„	16	0	0
Selenium	lb.		nom.	
Silicon 98%	ton		nom.	
Silver Spot Bars	oz.		6	4
Tellurium	lb.		15	0
Tin	ton	731	0	0
***Zinc**				
Electrolytic	ton		—	
Min 99·99%	„		—	
Virgin Min 98%	„	62	12	6
Dust 95/97%	„	104	0	0
Dust 98 99%	„	110	0	0
Granulated 99+%	„	87	12	6
Granulated 99·99+%	„	100	8	9

**Duty and Carriage to customers' works for buyers' account.*

INGOT METALS

Aluminium Alloy (Virgin)		£	s.	d.
B.S. 1490 L.M.5	ton	210	0	0
B.S. 1490 L.M.6	„	202	0	0
B.S. 1490 L.M.7	„	216	0	0
B.S. 1490 L.M.8	„	203	0	0
B.S. 1490 L.M.9	„	203	0	0
B.S. 1490 L.M.10	„	221	0	0
B.S. 1490 L.M.11	„	215	0	0
B.S. 1490 L.M.12	„	223	0	0
B.S. 1490 L.M.13	„	216	0	0
B.S. 1490 L.M.14	„	224	0	0
B.S. 1490 L.M.15	„	210	0	0
B.S. 1490 L.M.16	„	206	0	0
B.S. 1490 L.M.18	„	203	0	0
B.S. 1490 L.M.22	„	210	0	0

		£	s.	d.
†Aluminium Alloy (Secondary)				
B.S. 1490 L.M.1	ton	155	0	0
B.S. 1490 L.M.2	„	161	10	0
B.S. 1490 L.M.4	„	182	10	0
B.S. 1490 L.M.6	„	204	10	0

†Average selling prices for February

		£	s.	d.
***Aluminium Bronze**				
BSS 1400 AB.1	ton	201	0	0
BSS 1400 AB.2	„		—	
***Brass**				
BSS 1400-B3 65/35	„	129	0	0
BSS 249	„		—	
BSS 1400-B6 85/15	„		—	
***Gunmetal**				
R.C.H. 3/4% ton	ton		—	
(85/5/5/5)	„	154	0	0
(86/7/5/2)	„	165	0	0
(88/10/2/1)	„	215	0	0
(88/10/2/½)	„	222	0	0
Manganese Bronze				
BSS 1400 HTB1	„	167	0	0
BSS 1400 HTB2	„		—	
BSS 1400 HTB3	„		—	
Nickel Silver				
Casting Quality 12%	„		nom.	
„ „ 16%	„		nom.	
„ „ 18%	„		nom.	
***Phosphor Bronze**				
2B8 guaranteed A.I.D. released	„	240	0	0
Phosphor Copper				
10%	„	207	0	0
15%	„	215	0	0

** Average prices for the last week-end.*

		£	s.	d.
Phosphor Tin				
5%	ton		—	
Silicon Bronze				
BSS 1400-SB1	„		—	
Solder, soft, BSS 219				
Grade C Tinmans	„	345	6	0
Grade D Plumbers	„	279	6	0
Grade M	„	378	6	0
Solder, Brazing, BSS 1845				
Type 8 (Granulated)	lb.		—	
Type 9	„		—	
Zinc Alloys				
Mazak III	ton	93	13	9
Mazak V	„	97	13	9
Kayem	„	103	13	9
Kayem II	„	109	13	9
Sodium-Zinc	lb.		2	5

SEMI-FABRICATED PRODUCTS

Prices of all semi-fabricated products vary according to dimensions and quantities. The following are the basis prices for certain specific products.

Aluminium		£	s.	d
Sheet 10 S.W.G.	lb.		2	8
Sheet 18 S.W.G.	„		2	10
Sheet 24 S.W.G.	„		3	1
Strip 10 S.W.G.	„		2	8
Strip 18 S.W.G.	„		2	9
Strip 24 S.W.G.	„		2	10½
Circles 22 S.W.G.	„		3	2
Circles 18 S.W.G.	„		3	1
Circles 12 S.W.G.	„		3	0
Plate as rolled	„		2	7½
Sections	„		3	1½
Wire 10 S.W.G.	„		2	11
Tubes 1 in. o.d. 16 S.W.G.	„		4	0

		£	s.	d.
Aluminium Alloys				
BS1470. HS10W.	lb.			
Sheet 10 S.W.G.	„		3	0½
Sheet 18 S.W.G.	„		3	3
Sheet 24 S.W.G.	„		3	10½
Strip 10 S.W.G.	„		3	0½
Strip 18 S.W.G.	„		3	2
Strip 24 S.W.G.	„		3	10
BS1477 HP30M.				
Plate as rolled			2	10½
BS1470. HC15WP.				
Sheet 10 S.W.G.	lb.		3	6½
Sheet 18 S.W.G.	„		4	0½
Sheet 24 S.W.G.	„		4	10½
Strip 10 S.W.G.	„		3	9½
Strip 18 S.W.G.	„		4	0½
Strip 24 S.W.G.	„		4	8
BS1477. HPC15WP.				
Plate heat treated	„		3	5½
BS1475. HG10W.				
Wire 10 S.W.G.	„		3	9½
BS1471. HT10WP				
Tubes 1 in. o.d. 16 S.W.G.	„		4	11
BS1476. HE10WP.				
Sections	„		3	1
Beryllium Copper				
Strip	„	1	4	11
Rod	„	1	1	6
Wire	„	1	4	9
Brass Tubes	„		1	5½
Brazed Tubes	„		—	
Drawn Strip Sections	„		—	
Sheet	ton		—	
Strip	„		—	
Extruded Bar	lb.		1	8½
Extruded Bar (Pure Metal Basis)	„		—	
Condenser Plate (Yellow Metal)	ton	146	0	0
Condenser Plate (Naval Brass)	„	157	0	0
Wire	lb.		2	3
Copper Tubes	lb.		1	8¾
Sheet	ton	203	10	0
Strip	„	203	10	0
Plain Plates	„		—	
Locomotive Rods	„		—	
H.C. Wire	„	226	5	0
Cupro Nickel				
Tubes 70/30	lb.		3	1¾
Lead Pipes (London)	ton	115	5	0
Sheets (London)	„	113	0	0
Tellurium Lead	„	£6 extra		
Nickel Silver				
Sheet and Strip 7%	„		3	3
Wire 10%	„		3	9½
Phosphor Bronze				
Wire	„		3	6

Titanium (10,000 lb. lots)			
Billet 11″-4″	lb.	69/-	60/-
Wire ·315″-·036″	„	101/-	201/-
Sheet (4′/8′×2′) ·160″-·010″	„	100/-	158/-
Strip ·048″-·003″	„	100/-	350/-
Tube Representative gauge	„	320/-	
Extrusions	„	137/-	

		£	s.	d.
Zinc Sheets, English destinations	ton	96	5	0
Strip	„		nom.	

Financial News

Light Metal Statistics

Figures showing the U.K. production, etc., of light metals for Jan., 1958, have been issued by the Ministry of Supply as follow (in long tons):—

Virgin Aluminium	
Production	2,850
Imports	15,424
Despatches to consumers	18,043
Secondary Aluminium	
Production	10,583
Virgin content of above	1,122
Despatches (including virgin content)	10,778
Secondary in Consumption (per cent)	
Wrought products	5·9
Cast products	83·2
Destructive uses (aluminium content irrecoverable)	69·3
Total consumption	30·3
Scrap	
Arisings	12,853
Estimated quantity of metal recoverable	9,251
Consumption by:	
(a) Secondary smelters	12,091
(b) Other uses	1,174
Despatches of wrought and cast products	
Sheet, strip and circles	11,624
Extrusions (excluding forging bar, wire-drawing rod and tube shell):	
(a) Bars and sections	2,784
(b) Tubes (i) extruded	251
(ii) cold drawn	479
(c) (i) Wire	1,309
(ii) Hot rolled rod (not included in (c) (i)	58
Forgings	390
Castings: (a) Sand	1,806
(b) Gravity die	4,536
(c) Pressure die	1,638
Foil	2,619
Paste	250
Magnesium Fabrication	
Sheet and strip	9
Extrusions	22
Castings	202
Forgings	1

Edwards High Vacuum Ltd.

Final dividend 11 per cent, making 15 per cent for 1957 (same). Consolidated net profit £76,458 (£85,039), after tax of £103,178 (£94,403). Deduct minority interests £313 (£164). Add provision made out of profits of previous years no longer required in respect of trade investment £8,322 (nil). Off trade investment nil (£4,513), retained subsidiaries £692 (£14,503), to general reserve £40,000 (£25,000), forward £35,122 (£35,766).

British Rollmakers Corpn.

Group profit, after tax, 1957, £415,333 (£301,183) and dividend 14 per cent (12 per cent). Group fixed assets £2,810,678 (£2,701.025). Net current assets £1,782,574 (£1,476,482). Deferred liabilities, future tax and tax equalization £631,747 (£570.095). Capital reserves £397,131 (£307,131). Revenue reserves and surplus £1,102,906 (£838,813). Commitments £413,000 (£350,000).

Le Grand Sutcliff and Gell

Net profit for 15 months ended December 31, 1957, £64,400 (£15,054 for previous year), after tax of £61,656 (£37,895). Forward £83,060 (£35,906).

New Companies

The particulars of companies recently registered are quoted from the daily register compiled by Jordan and Sons Limited, Company Registration Agents, Chancery Lane, W.C.2.

Austin Richardson and Co. Limited (600056), 7 Old Steine, Brighton. Registered March 6, 1958. To take over business of scrap metal and textile waste merchants carried on at Brighton by Geo. E. Richardson, etc. Nominal capital, £10,000 in £1 shares. Directors: Arthur F. L. Austin, George C. Richardson and Bernard W. Richardson.

Albany Components Limited (600103), 6 Albany Road, N.15. Registered March 7, 1958. To carry on business of metal turners, fitters and welders, etc. Nominal capital, £1,000 in £1 shares. Directors: Ronald A. Berryman, Charles B. Hickford, Ernest W. Nevill and Henry H. Horsley.

Trade Publications

Morgan Refractories. — The Morgan Crucible Company Ltd., Battersea Church Road, London, S.W.11.

A four-page leaflet has been issued by this company drawing attention to their "Tri-Mor" high-temperature mouldable refractory, which has a 60 per cent alumina content, resulting, states the leaflet, in high refractoriness and exceptional resistance to fuel-oil slags. The principal physical characteristics of this unit are described as follows—maximum service temperature, 1,650°C.; refractoriness Seger cone 33-34 (1,730°-1,750°C.); shrinkage, from set to dry not greater than 0·75 per cent; shrinkage, from dry material to material fired 1 hr. at 1,620°C., not greater than 0·1 per cent. Morgan Refractories Ltd. have developed a range of these "Tri-Mor" refractories that can be fired *in situ*.

Metal Finishing. — Roto-Finish Limited, Mark Road, Hemel Hempstead, Herts.

In the latest available issue of "Roto-Finish Roundabout," the house journal of this company, some interesting details are given of the new European metal finishing division of the company. The background of this division and the various products which it is handling are described, together with several illustrations.

Scrap Metal Prices

Merchants' average buying prices delivered, per ton, 22/4/58.

	£
Aluminium	
New Cuttings	143
Old Rolled	120
Segregated Turnings	89
Brass	
Cuttings	113
Rod Ends	110
Heavy Yellow	95
Light	90
Rolled	105
Collected Scrap	93
Turnings	105
Copper	
Wire	150
Firebox, cut up	150
Heavy	145
Light	140
Cuttings	150
Turnings	137
Braziery	120
Gunmetal	
Gear Wheels	150
Admiralty	150
Commercial	124
Turnings	120
Lead	
Scrap	63
Nickel	
Cuttings	—
Anodes	500
Phosphor Bronze	
Scrap	124
Turnings	120
Zinc	
Remelted	53
Cuttings	40
Old Zinc	30

The latest available scrap prices quoted on foreign markets are as follow. (The figures in brackets give the English equivalents in £1 per ton):—

West Germany (D-marks per 100 kilos):		
Used copper wire	(£156.12.6)	180
Heavy copper	(£152.5.0)	175
Light copper	(£130.10.0)	150
Heavy brass	(£100.0.0)	115
Light brass	(£69.12.6)	80
Soft lead scrap	(£57.10.0)	66
Zinc scrap	(£39.2.6)	45
Used aluminium unsorted	(£87.0.0)	100
France (francs per kilo):		
Copper	(£200.2.6)	230
Heavy copper	(£200.2.6)	230
Light brass	(£148.0.0)	170
Zinc castings	(£67.0.0)	77
Tin	(£565.10.0)	650
Aluminium pans (98½ per cent)	(£130.10.0)	150
Italy (lire per kilo):		
Aluminium soft sheet clippings (new)	(£188.10.0)	325
Aluminium copper alloy	(£101.10.0)	175
Lead, soft, first quality	(£84.2.6)	145
Lead, battery plates	(£49.7.6)	85
Copper, first grade	(£174.0.0)	300
Copper, second grade	(£162.10.0)	280
Bronze, first quality machinery	(£177.0.0)	305
Bronze, commercial gunmetal	(£148.0.0)	255
Brass, heavy	(£124.15.0)	215
Brass, light	(£113.2.6)	195
Brass, bar turnings	(£127.12.6)	220
New zinc sheet clippings	(£55.2.6)	95
Old zinc	(£40.12.6)	70

THE STOCK EXCHANGE

Markets Became Rather Subdued With A Slackening Off in Prices

ISSUED CAPITAL ●	AMOUNT OF SHARE	NAME OF COMPANY	MIDDLE PRICE 22 APRIL	+RISE —FALL	DIV. FOR LAST FIN. YEAR	DIV. FOR PREV. YEAR	DIV. YIELD	1958 HIGH	1958 LOW	1957 HIGH	1957 LOW
£	£				Per cent	Per cent					
4,435,792	1	Amalgamated Metal Corporation ...	19/6	+3d.	10	10	10 5 3	19/9	17/9	28/3	18/-
400,000	2/-	Anti-Attrition Metal	1/6		8½	4	5 6 9	1/6	1/3	2/6	1/6
33,639,483	Stk. (£1)	Associated Electrical Industries ...	50/3	—3d.	15	15	5 19 6	51/-	47/-	72/3	47/9
1,590,000	1	Birfield Industries	50/3	—9d.	15	20N	5 19 6	53/9	49/6	70/-	48/9
3,196,667	1	Birmid Industries	65/6	+5/-	17½	17½	5 7 0	65/6	56/3	80/6	55/9
5,630,344	Stk. (£1)	Birmingham Small Arms	27/9	+2/1½	10	8	7 4 3	27/9	23/9	33/-	21/9
203,150	Stk. (£1)	Ditto Cum. A. Pref. 5%	15/7½		5	5	6 8 0	15/7½	14/7½	16/-	15/-
350,580	Stk. (£1)	Ditto Cum. B. Pref. 6%	16/10½		6	6	7 2 3	17/-	16/6	19/-	16/6
500,000	1	Bolton (Thos.) & Sons	26/10½		12½	12½	9 6 0	28/9	26/10½	30/3	28/9
300,000	1	Ditto Pref. 5%	15/6		5	5	6 9 0	—		16/9	14/3
160,000	1	Booth (James) & Co. Cum. Pref. 7%	19/3		7	7	7 5 6	19/3	19/-	22/3	18/9
9,000,000	Stk. (£1)	British Aluminium Co.	41/-xd	—2/4½	12	12	5 17 0	46/6	41/-	72/-	38/3
1,500,000	Stk. (£1)	Ditto Pref. 6%	19/-xd		6	6	6 6 3	19/3	18/4½	21/6	18/-
15,000,000	Stk. (£1)	British Insulated Callender's Cables	43/9	+1/6	12½	12½	5 14 3	43/9	38/10½	55/-	40/-
17,047,166	Stk. (£1)	British Oxygen Co. Ltd., Ord ...	35/3		10	10	5 13 6	35/3	29/-	39/-	29/6
600,000	Stk. (5/-)	Canning (W.) & Co.	20/6	—4½d.	25* 2½C	25	6 2 0	21/-	20/1½	24/6	19/3
60,484	1/-	Carr (Chas.)	2/1½		25	25	X8 4 9	2/3	2/-	3/6	2/1½
150,000	2/-	Case (Alfred) & Co. Ltd.	4/6		25	25	11 2 3	4/9	4/4½	4/6	4/-
555,000	1	Clifford (Chas.) Ltd.	16/9xd	+6d.	10	10	11 18 9	17/-	16/-	20/6	15/9
45,000	1	Ditto Cum. Pref. 6%	15/10½		6	6	7 11 3	—		17/6	16/-
250,000	2/-	Coley Metals	3/6		25	25	14 5 9	4/6	3/3	5/7½	3/9
8,730,596	1	Cons. Zinc Corp.†	49/3	+1/6	22½	22½	9 2 9	51/6	43/-	92/6	49/-
1,136,233	1	Davy & United	46/6		15	12½	6 9 0	48/-	45/9	60/6	42/6
2,750,000	5/-	Delta Metal	18/9xd	+3d.	30	*17½	8 0 0	21/4½	18/9	28/6	19/-
4,160,000	Stk. (£1)	Enfield Rolling Mills Ltd.	32/-	+6d.	15B	22½	7 16 3	32/-	24/-	38/6	25/-
500,000	1	Evered & Co.	41/-	+2/-	15	15	7 6 3	41/3	39/-	52/9	42/-
18,000,000	Stk. (£1)	General Electric Co.	33/-	+3d.	12½	14	Y 6 19 6	38/7½	29/6	59/-	38/-
1,250,000	Stk. (10/-)	General Refractories Ltd.	32/6xd		20	17½	6 3 0	33/9	27/3	37/-	26/9
401,240	1	Gibbons (Dudley) Ltd.	65/-		15	12	4 12 3	66/3	64/-	71/-	53/-
750,000	5/-	Glacier Metal Co. Ltd.	6/-		11½	11½	9 11 9	6/-	5/7½	8/1½	5/10½
1,750,000	5/-	Glynwed Tubes	13/3xd		20	20	7 11 0	13/6	12/10½	18/-	12/6
5,421,049	10/-	Goodlass Wall & Lead Industries ...	22/-	+6d.	18Z	16	5 9 0	22/-	19/3	37/3	28/9
342,195	1	Greenwood & Batley	46/9		17½	17½	7 9 9	46/10½	45/-	50/-	46/-
396,000	5/-	Harrison (B'ham) Ord.	12/1½	+1½d.	*15	*30‡	6 3 9	12/4½	11/6	16/9	12/4½
150,000	1	Ditto Cum. Pref. 7%	18/9		7	7	7 9 3	—		22/3	18/7½
1,075,167	5/-	Heenan Group	7/3		10	20‡	6 18 0	7/7½	6/9	10/4½	6/9
142,045,750	Stk. (£1)	Imperial Chemical Industries ...	44/-xd		12Z	10	5 9 0	44/10½	36/6	46/6	36/3
33,708,769	Stk. (£1)	Ditto Cum. Pref. 5%	16/3		5	5	6 3 0	17/1½	16/-	18/6	15/6
14,584,025	**	International Nickel	136½	+2½	$3.75	$3.75	4 18 3	144½	134	222	130
430,000	5/-	Jenks (E. P.), Ltd.	7/-xcap	+3d.	27½ ϕ	27½	9 16 6	7/9¾	6/9	18/10½	15/1½
300,000	1	Johnson, Matthey & Co. Cum. Pref. 5%	16/3		5	5	6 3 0	16/3	15/-	17/-	14/6
3,987,435	1	Ditto Ord.	42/6	+2/-	10	9	4 14 0	42/6	37/6	58/9	40/-
600,000	10/-	Keith, Blackman	16/3		15	15	9 4 6	16/3	15/-	21/9	15/-
160,000	4/-	London Aluminium	3/1½		10	5	12 16 0	4/3	3/1½	6/9	3/6
2,400,000	1	London Elec. Wire & Smith's Ord....	43/9		12½	12½	5 14 3	43/9	39/9	54/6	41/-
400,000	1	Ditto Pref.	22/3	—6d.	7½	7½	6 14 9	22/9	22/3	25/3	21/9
765,012	1	McKechnie Brothers Ord.	32/6		15	15	9 4 6	35/-	32/6	48/9	37/6
1,530,024	1	Ditto A Ord.	30/-		15	15	10 0 0	32/6	30/-	47/6	36/-
1,108,268	5/-	Manganese Bronze & Brass	10/6		27½‡	25	6 11 0	10/6	9/-	21/10½	7/6
50,628	6/-	Ditto (7½% N.C. Pref.)	6/-		7½	7½	7 10 0	6/-	5/9	6/6	5/-
13,098,855	Stk. (£1)	Metal Box	48/6		20‡	15M	4 2 6	48/6	41/9	59/-	40/3
415,760	Stk. (2/-)	Metal Traders	6/3	—3d.	50	50	16 0 0	6/6	6/3	8/-	6/3
160,000	1	Mint (The) Birmingham	21/9		10	10	9 4 0	22/9	21/9	25/-	21/6
80,000	5	Ditto Pref. 6%	83/6		6	6	7 3 9	—		90/6	83/6
3,064,930	Stk. (£1)	Morgan Crucible A	40/-		10	11	5 0 0	40/-	34/-	54/-	35/-
1,600,000	Stk. (£1)	Ditto 5½% Cum. 1st Pref. ...	17/-		5½	5½	6 9 6	17/3	17/-	19/3	16/-
2,200,000	Stk. (£1)	Murex	53/6		20	20	7 9 6	57/6	53/6	79/9	57/-
468,000	5/-	Ratcliffs (Great Bridge)	7/1½xd		10	10	7 0 3	7/3	6/10½	8/-	6/10½
234,960	10/-	Sanderson Bros. & Newbould ...	27/-		27½D	27½	6 15 9	27/-	26/-	41/-	24/9
1,365,000	Stk. (5/-)	Serck	12/3	—1½d.	17½Z	15	4 15 3	12/4½	11/-	18/10½	11/6
600,400	Stk. (£1)	Stone (J.) & Co. (Holdings)	43/9		16	16	7 6 6	—		57/6	43/9
600,000	1	Ditto Cum. Pref. 6½%	20/3		6½	6½	6 8 6	20/3	20/-	21/9	18/9
14,494,862	Stk. (£1)	Tube Investments Ord.	53/6	—1/-	15	15	5 12 3	54/6	48/4½	70/9	50/6
41,000,000	Stk. (£1)	Vickers	32/6	+9d.	10	10	6 3 0	32/6	29/4½	46/-	29/-
750,000	Stk. (£1)	Ditto Pref. 5%	15/6		5	5	6 9 0	15/6	14/9	18/-	14/-
6,863,807	Stk. (£1)	Ditto Pref. 5% tax free	22/-		*5	*5	6 19 9A	23/-	21/3	24/9	20/7½
2,200,000	1	Ward (Thos. W.), Ord.	76/3	+6d.	20	15	5 5 0	76/3	70/9	83/-	64/-
2,666,034	Stk. (£1)	Westinghouse Brake	38/-	+3d.	10	18P	5 5 3	38/-	32/6	85/-	29/1½
225,000	2/-	Wolverhampton Die-Casting ...	7/10½xd		25	40	6 7 0	8/-	7/2½	10/1½	7/-
591,000	5/-	Wolverhampton Metal	16/6	+1½d.	27½	27½	8 6 9	16/6	14/9	22/3	14/9
78,465	2/6	Wright, Bindley & Gell	3/3		20	17½E	15 7 9	3/9¾	3/3	3/9	2/7½
124,140	1	Ditto Cum. Pref. 6%	11/6		6	6	10 8 9	—		12/6	11/3
150,000	1/-	Zinc Alloy Rust Proof	2/10½		40D	33⅓	9 5 6	3/1½	2/7½	5/-	2/9

*Dividend paid free of Income Tax. †Incorporating Zinc Corpn. & Imperial Smelting **Shares of no Par Value. ‡ and 100% Capitalized issue. ● The figures given relate to the issue quoted in the third column. A Calculated on £7 14 6 gross. H and 200% capitalized issue. M and 10% capitalized issue. Y Calculated on 11½% dividend. ||Adjusted to allow for capitalization issue. E for 15 months. P and 100% capitalized issue, also "rights" issue of 2 new shares at 35/- per share or £3 stock held. D and 50% capitalized issue. Z and 50% capitalized issue. B equivalent to 12½% on existing Ordinary Capital after 100% capitalized issue. ϕ And 100% capitalized issue. X Calculated on 17½%. C Paid out of Capital Profits.